Executive Functioning in Children With Autism and Co-Occurring Neurodevelopmental Disorders: A Systematic Review and Quantitative Analysis

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EXECUTIVE FUNCTIONING IN CHILDREN WITH AUTISM AND CO-OCCURRING NEURODEVELOPMENTAL DISORDERS:
A SYSTEMATIC REVIEW AND QUANTITATIVE ANALYSIS

by
Kandice Benallie

A dissertation submitted in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY in Psychology

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UTAH STATE UNIVERSITY
Logan, Utah
2023
ABSTRACT

Executive Functioning in Children with ASD and Co-Occurring Neurodevelopmental Disorders: A Systematic Review and Quantitative Analysis

by

Kandice Benallie, Master of Science

Utah State University, 2023

Major Professor: Dr. Maryellen McClain Verdoes
Department: Psychology

Children with NDDS often have associated EF impairments. It can be challenging to differentiate autism from other NDDs. Inaccurate diagnostic evaluations negatively impact access to appropriate interventions. This is especially true with ADHD and ID, the most common co-occurring NDDs with autism. Research shows EF impairments are unique to diagnostic groups and therefore have the potential to inform differential diagnostic decisions. However, further research is necessary to confirm EF differences across specific disabilities and determine appropriate clinical applications given the limited and inconsistent findings of the current literature. This dissertation seeks to identify unique EF strengths and impairments in autistic children, autism+ADHD, and autism+ID. A systematic review was conducted that examined unique EF presentations among children with autism+ADHD and autism+ID. Our findings generally revealed that a co-occurring ADHD or ID resulted in more executive dysfunction among autistic children. Additionally, findings also support previous research findings that performance-based and indirect measures of EF measure different constructs.
The findings of the systematic review informed the second study which investigated how intellectual functioning, autism symptomology, and ADHD symptomology predict the EF of autistic children using an indirect EF assessment measure. Results suggest that social communication difficulties and hyperactivity/impulsivity negatively impact EF whereas restricted/repetitive behaviors, inattention, and intellectual functioning do not significantly predict EF. A second purpose of our study was to use a theory of EF proposed by Gioia and colleagues (2015) to identify relative EF presentations among autistic children. Findings suggest that autistic children demonstrate a relative weakness with emotion regulation as compared to behavior and cognitive regulation. These preliminary findings provide information about how an indirect measure of EF can be used as a diagnostic tool to inform differential diagnosis as well as provide areas of EF to target with intervention.

This dissertation addresses the limited and contradictory preexisting research assessing the impact of ADHD and ID characteristics on EF by providing further information about how co-occurring ADHD and ID impact the EF of autistic children using an indirect measure of EF (due to its ecological validity) and a model of EF (due to the overlapping nature of areas of EF).

(376 pages)
PUBLIC ABSTRACT

Executive Functioning in Children with ASD and Co-Occurring Neurodevelopmental Disorders: A Systematic Review and Quantitative Analysis

Kandice Benallie

Children with autism and other NDDs experience some level of executive dysfunction including challenges with problem-solving, judgement, working memory, and flexibility. Considering autism and other NDDs including ADHD and ID have overlapping symptoms, it can be difficult to differentially diagnose the disorders. This dissertation sought to explore how co-occurring ADHD and ID impact the EF of autistic children. The first study systematically reviewed the current research examining EF of autistic children with co-occurring ADHD and ID. Findings suggest that co-occurring ADHD and ID result in increased executive dysfunction as compared to children with autism only. The systematic review also revealed inconsistencies in the current literature as well as supported previous research suggesting that different ways of measuring EF (i.e., performance-based vs. indirect) are measuring different constructs of EF. This led to the second study which investigated whether intellectual functioning, autism symptomology, and ADHD symptomology predict EF in autistic children using an indirect measure of EF and (due to its ecological validity) and a model of EF (due to the overlapping nature of areas of EF). Results suggest that social communication difficulties and hyperactivity/impulsivity negatively impact EF whereas restricted/repetitive behaviors, inattention, and intellectual functioning do not significantly predict EF. Additionally, the student identified emotion regulation as a relative EF weakness as
compared to behavior and cognitive regulation. Overall, this multi-part dissertation adds to the current literature by suggesting a co-occurring ADHD or ID worsens EF; suggested significant predictors of EF with autistic children (i.e., social communication challenges and hyperactivity/impulsivity); and, identified emotion regulation as a possible relative EF weakness. These results provide clinical application for differential diagnostic strategies and targeted interventions.
ACKNOWLEDGMENTS

Thank you to all my friends, family, and mentors for their constant encouragement, support, and patience throughout my graduate career. A special thanks goes to my partner as he not only provided me significant emotional support and patience but also moved across the country with our young daughter to support me as I completed my doctoral internship. There were many tears and hardships through this process, and I could not have completed this dissertation or my degree without you all.

I also want to thank Psi Chi for providing me a Graduate Research Grant to financially support this dissertation as well as my co-authors for assisting me in completing the first study, Executive Functioning in Children with ASD+ADHD and ASD+ID: A Systematic Review.

Kandice Benallie
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CHAPTER I
GENERAL INTRODUCTION

Autism

Autism\(^1\) is a neurodevelopmental disorder (NDD) that develops in early childhood and persists throughout an individual’s life (American Psychiatric Association [APA], 2022). Individual symptoms and behaviors associated with autism vary in presentation and severity. There are two primary diagnostic criteria for autism: 1) social communication and interaction deficits and 2) restricted and repetitive interests, behaviors, and activities (APA, 2022). In a little over a decade—2006 to 2020—the prevalence of autism has more than tripled from 1 in 110 children to 1 in 36 children (Maenner et al., 2023). Current prevalence estimates suggest that just under 3% of children in the United States are impacted by autism (Maenner et al., 2023). Furthermore, children with a special education (SPED) classification of Autism (AU) currently comprise 10% of all children receiving SPED services in United States public schools (U.S. Department of Education, Office of Special Education and Rehabilitation Services, 2019). Similar to the diagnostic prevalence of ASD, the SPED classification of AU has increased two-fold in the last decade, from 4.5% in 2008 to 10.2% in 2017 (U.S. Department of Education, Office of Special Education and Rehabilitation Services, 2019). The upward trend of prevalence indicates that autism is one of the fastest-growing NDDs in the United States (CDC, 2020; U.S. Department of Education, Office of Special Education and Rehabilitation Services, 2019).

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\(^1\) The terms “ASD” and “autism” will be used interchangeably throughout to represent the identity preferences of those with the disorder.
Assessment of Autism

Varied and complex symptomology across autistic children engenders a further complicated identification process. Best practice suggests that a comprehensive evaluation be conducted to present an inclusive picture of the child’s behavior. A comprehensive evaluation includes a developmental and medical history; inclusion of autism-specific, cognitive, and language/communication assessments; as well as social-emotional, behavioral, and adaptive skill questionnaires (Di Renzo et al., 2019; Kronke et al., 2016; Manning-Courtney et al., 2013). Furthermore, an interdisciplinary approach that includes professionals from several disciplines such as psychology, speech-language pathology, medicine, and occupational therapy, is considered best practice and highlights a range of developmental strengths and weaknesses of the child (Campbell et al., 2020). Autism evaluations that are not comprehensive nor interdisciplinary may not fully describe the child’s functioning or attribute the symptoms or behaviors appropriately (i.e., differentiate behaviors from other disorders or determine a co-occurring disorder). This may result in individuals not receiving an appropriate diagnosis and subsequently inappropriate recommendations and services.

Common Co-occurring Neurodevelopmental Disorders

Two of the most common co-occurring NDDs with autism are intellectual disability (ID) and attention-deficit/hyperactivity disorder (ADHD; Hyman et al., 2020). Determining a differential or co-occurring diagnosis of ID or ADHD from autism is made complicated by the complex symptomology of autism in addition to frequently overlapping characteristics between autism and other NDDs. ID co-occurs with autism in approximately 38% of cases (Maenner et al., 2023). ID is classified when an individual
displays normatively low intellectual abilities and adaptive skills (APA, 2022). Children with ID also exhibit language, reasoning, knowledge, and interpersonal skills difficulties as well as social skills deficits, repetitive speech, and restricted behaviors (Thurm et al., 2019; Trammel et al., 2013). These behaviors and characteristics are also common in autistic children. Autistic children with a co-occurring ID typically demonstrate the behaviors mentioned previously as well as significantly lower intellectual abilities and adaptive skills than would be expected for their developmental age (Thurm et al., 2019). Ruling out autism in a child with ID requires considerations about whether social communication and restricted/repetitive behaviors can be fully explained by ID. The high co-occurring rate of autism and ID and overlapping symptomology warrants special attention to discerning autism and ID as well as determining if a co-occurring ID is present with autism.

ADHD and autism also share several common behaviors and characteristics. Classic behaviors associated with ADHD include not being able to focus on tasks, poor attention to detail, difficulties listening and following through with tasks, being easily distracted, difficulties with planning and organizing, as well as significant hyperactivity and impulsivity (APA, 2022; Barkley, 2022; Tye et al., 2013). Similarly, autistic children often exhibit difficulties transitioning, challenges attending to tasks at hand, and are easily distracted (APA, 2022; Mayes et al., 2012). Although these behaviors are associated with ADHD, the function of the behavior is telling of whether the child has ADHD or autism. For example, autistic children who have problems attending to tasks may be hyper-focused on a special interest and therefore are not attending to another task, whereas a child with ADHD would likely have difficulties attending across various
activities and settings (Deprey and Ozonoff, 2009; Mikami et al., 2019). Additionally, difficulties with social skills and communication are common in both children with ASD and ADHD (APA, 2022); however, the reasoning behind the social impairments may differ between the two diagnoses. Associated behaviors of ADHD (e.g., difficulties waiting, blurting out responses in class) often result in difficulties with peer relations (Antshet & Russo, 2019). In addition, children with ADHD often actively seek relationships whereas autistic children may be interested in relationships but lack the social skills to pursue and maintain relations (Antshet & Russo, 2019). Like ID, a differential or co-occurring diagnosis of ADHD is necessary to investigate when a child is diagnosed with autism, considering the high overlap with symptoms and behaviors.

**Executive Functioning**

Higher-order cognitive functioning that involves adapting and responding to new situations is known as executive functions (EF; Lezak, 2012). Furthermore, EF skills are used to respond flexibly to novel situations and environments (Elliot, 2003) and play an important role in an individual’s cognitive, emotional, and social skills (Lezak, 2012). The quality in which an individual completes academic, occupational, and daily living tasks is likely impacted by their EF skills. Specific EF skills include inhibition, cognitive flexibility, planning and organizing, attention, and self-regulation, among others (e.g., Elliot, 2003; Lezak, 2012).

**Executive Functioning in Children with Autism and Co-occurring NDDs**

Autism, along with other NDDs, is often associated with considerable EF difficulties (e.g., APA, 2022; Benallie et al., 2021; Channon et al., 2003; Corbett et al.,
2009; Craig et al., 2016; Henry et al., 2010; Otterman et al., 2019). Considering that NDDs are associated with neurological and developmental impairments, it is not surprising that individuals with an NDD have difficulties with EF skills. Due to the complexity and variability among EF skills as well as the similarities in symptomology across NDDs, there is likely significant overlying and differing EF skills and impairments among children with various NDDs. Children with ASD are known to have specific EF challenges with vigilance (Corbett et al., 2009), inhibition (Corbett et al., 2009; Demetriou et al., 2018; Hill, 2004), cognitive flexibility and switching (Corbett et al., 2009; Demetriou et al., 2018; Hill, 2004; Lai et al., 2017), planning (Benallie et al., 2021; Demetriou et al., 2018; Hill, 2004; Lai et al., 2017), and working memory (Corbett et al., 2009; Demetriou et al., 2018; Lai et al., 2017).

Considering that many children with NDDs have EF impairments (e.g., APA, 2022; Benallie et al., 2021; Channon et al., 2003; Corbett et al., 2009; Craig et al., 2016; Henry et al., 2010; Otterman et al., 2019), those with two or more co-occurring NDDs (e.g., ASD+ID, ASD+ADHD) may present with unique EF strengths and weaknesses. Although limited, research supports that unique EF impairments are observed when ID or ADHD are present in individuals with ASD. Specifically, children with ASD+ADHD have more impairments with EF skills broadly (Dajani et al., 2016) and with inattention (Craig et al., 2015) compared to autistic children. It has also been shown that inhibition, sustained attention, and focusing are more impaired in children with ASD+ADHD compared to those with autism (Benallie et al., 2021; Hwang-Gu et al., 2019; Rosello et al., 2022). Worsened working memory deficits are associated with children with ASD+ID when compared to others with ID (Trezise et al., 2014). Research has also shown that a
diagnosis of ASD+ID results in relatively better attention skills than a diagnosis of ADHD or ASD+ADHD (McClain et al., 2017). Conversely, Panerai and colleagues (2014) observed that overall EF, inhibition, emotional control, working memory, planning, and monitoring skills were more impaired in children with ASD only compared to their ASD+ID counterparts.

**Summary**

Autism is complex with heterogenous symptomology (APA, 2022). Co-occurring diagnoses of ADHD and ID can make this presentation more complicated due to the overlap and differences in symptomology across these disorders (e.g., APA, 2022; Craig et al., 2015). Impairments in EF are common across NDDs, notably autism, ADHD, and ID (e.g., APA, 2022; Benallie et al., 2021; Channon et al., 2003; Corbett et al., 2009; Craig et al., 2016; Henry et al., 2010; Otterman et al., 2019). However, differences in specific EF skills among autistic children and other NDDs are not well understood. To provide the most beneficial and appropriate services to children and their families, they must be accurately identified and evaluated. By assessing the differences in EF skills, clinicians can be better informed regarding how to differentiate autism from other NDDs and be aware of how autism presents with co-occurring ADHD and ID. Furthermore, understanding relative EF strengths and limitations can inform targeted interventions that utilize strengths and improve weaknesses.

The purpose of this dissertation is to examine how co-occurring ADHD and ID symptomology impact the EF of autistic children. The first study examined the current literature regarding EF in children with ASD+ADHD and ASD+ID through a systematic
review. The systematic review had three goals: 1) report on comparisons between the two diagnostic groups of interest (i.e., ASD+ADHD and ASD+ID) and the ASD-only diagnostic group; 2) reveal potential unique EF strengths and impairments relative to ASD+ADHD and ASD+ID; and 3) compare reports of indirect and performance-based measures of EF. The second study examined how intellectual functioning, autism symptom severity, and ADHD symptom severity impact the EF of school-aged autistic children using an indirect assessment of EF (i.e., Behavior Rating Inventory of Executive Function, Second Edition [BRIEF-2]; Gioia et al., 2015).
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attention deficit hyperactivity disorder and typical development. *Psychiatry research, 166*(2-3), 210-222.


CHAPTER II

EXECUTIVE FUNCTIONING IN CHILDREN WITH ASD+ID AND ASD+ADHD: A SYSTEMATIC REVIEW

The first manuscript is titled, *Executive Functioning in Children with ASD+ID and ASD+ADHD: A Systematic Review*. The authors are Kandice J. Benallie, Maryellen McClain Verdoes, Kaelah Bakner, Tyus Roanhorse, and Jennifer Ha. The manuscript was submitted to *Research in Autism Spectrum Disorders* on November 7, 2020, returned for revisions on May 19, 2021, and accepted on May 26, 2021. The remainder of this chapter is the pre-print of the accepted manuscript. The journal print version can be found at https://doi.org/10.1016/j.rasd.2021.101807. The remainder of this chapter is the pre-print of the submitted manuscript. Co-authors Kaelah Bakner, Tyus Roanhorse, and Jennifer Ha provided permission for the inclusion of this study in this dissertation (see Appendix A).

Abstract

Executive functions (EF) are skills that impact an individual’s ability to flexibly and efficiently problem solve and react to their environment. Children with neurodevelopmental disorders (NDDs), such as autism spectrum disorder (ASD), commonly experience EF deficits. However, it is unclear how a co-occurring diagnosis of attention-deficit/hyperactivity disorder (ADHD) or intellectual disability (ID) impact EF in children with ASD. This study systematically reviewed 26 studies – within 24 journal articles – that examined EF among children with ASD + ADHD and ASD + ID. Results
revealed many non-congruent findings regarding EF in children with ASD + ADHD and ASD + ID, including differences across performance-based and indirect measures of EF. Children with ASD + ADHD exhibited unique flexibility and shifting, inhibition, and attention deficits. Among children with ASD + ID, planning and organizing, flexibility and shifting, attention, behavior regulation, and global EF skills significantly differed from comparison groups. Notably, these findings were dependent on assessment type used (performance-based versus indirect). Furthermore, analyses of mean Z-scores suggest that children with ASD + ADHD and ASD + ID exhibited more severe EF impairments than children with ASD. These results may be used to inform assessment practices for differentiating and determining co-occurring diagnoses. Understanding unique EF deficits may also inform the development of targeted treatment and interventions.

Introduction

Defining and measuring executive functioning (EF) has not reached a consensus (Barkley, 2012), but EF is broadly defined as higher order cognitive processes that allow an individual the flexibility to adapt and respond to novel stimuli or situations in their environment (Elliot, 2003; Lezak, 2012). Multiple models of EF have been developed that conceptualize EF based on volition (using a choice to intentionally behave), planning and decision making (using planning and organization steps to solve problems), purposive action (intentionally taking steps towards implementing a plan), and effective performance (monitoring and regulating one’s own actions). Specific areas of EF—though not an exhaustive list—include working memory, inhibition, cognitive flexibility
and shifting, planning and organizing, attention, and self-regulation (e.g., Elliot, 2003; Lezak, 2012). As the purpose of this paper is not to discuss the various types and functions of EF in detail, interested readers should reference Barkley (2012), Elliot (2003), and Lezak (2012). The significant role that EF skills contribute to daily functioning is apparent in an individual’s emotional, cognitive, and social skills and impact academic, occupational, and social functioning. Neurodevelopmental disorders (NDDs)—such as autism spectrum disorder (ASD), intellectual disability (ID), and attention-deficit/hyperactivity disorder (ADHD)—have been associated with significant EF skill deficits (Craig et al., 2016; Henry et al., 2010).

**Measuring EF**

EF assessments use indirect (e.g., behavior rating forms) and performance-based (e.g., in-person administered assessment) approaches. Research has shown that indirect and performance-based (e.g., clinician-administered measures) measures of EF abilities may be measuring different constructs of EF altogether (Miranda et al., 2015; Toplak et al., 2013). EF behavior rating scales were developed to assess abilities of everyday problem-solving in the context of the real world (Roth et al., 2005). In contrast, performance-based measures of EF are conducted in a highly controlled and standardized fashion to ensure that examinees have the same experience with a single examiner to maintain consistency. However, this controlled environment does not allow the examiner to observe the examinee’s true EF abilities in a real-world context. Toplak et al. (2013) suggest that indirect and performance-based measures of EF may offer clinically relevant information regarding different levels of cognitive processing. Specifically, performance-based assessments examine an individual’s ability to efficiently problem solve (i.e.,
algorithmic mind), whereas indirect measures assess an individual’s ability to make decisions and problem solve based on their goals and beliefs (i.e., reflective mind).

Furthermore, Miranda et al. (2015) reported moderate correlations between behavior rating scales and performance-based measures of EF, but only at the domain level. For example, metacognition (i.e., Behavior Rating Inventory of Executive Functions, Second Edition [BRIEF-2]; Gioia et al., 2015) correlates with verbal working memory (i.e., working memory-counting task), however, metacognition did not correlate with inhibition (i.e., Sun-Moon Stroop task, tapping task). The authors hypothesized that the BRIEF-2 (i.e., indirect measure) may be assessing the behavioral component of EF, whereas performance-based measures seem to be focused on examining the cognitive component of EF. While both performance-based and indirect assessments measure some component EF, the behavior ratings scales – indirect assessments – may be more ecologically valid and meaningful to measure.

**Autism and Neurodevelopmental Disorders**

ASD is an NDD characterized by deficits in social communication and interaction skills, as well as patterns of restricted and repetitive behaviors and interests (American Psychiatric Association [APA], 2013). The prevalence of ASD has been increasing with almost 3% of children in the United States meeting criteria (Maenner et al., 2023). Considering the substantial impact that ASD may have on individuals (e.g., relationally, academically, occupationally) and the increased prevalence, it is crucial that ASD is appropriately identified. Early identification is another important factor that has the potential to result in earlier access to services by the child and family. Early intervention services (<5 years) have been shown to greatly improve outcomes of individuals with
ASD (e.g., Debodiance et al. 2017; Hampton and Kaiser 2016; Peters-Scheffer et al. 2011; Reichow 2012). The complexity and variability of ASD symptom presentation can make an accurate identification, differential diagnosis, and co-occurring diagnoses with other NDDs that share similar topography (e.g., ADHD, ID) difficult for clinicians. ADHD and ID are NDDs that most often co-occur with ASD (Taurines et al., 2012; Thurm et al., 2019). ADHD is characterized by significant hyperactivity/impulsivity and/or inattention, whereas the presence of ID is determined by considerable intellectual and adaptive functioning deficits – all of which emerge during the developmental period (APA, 2013). Children with ADHD and ID may also exhibit similar social communication and interaction deficits and restricted behaviors (Grzdzinski et al., 2010; Lecavalier et al., 2011; Mayes et al., 2012; Staikova et al., 2013), such as difficulties making and maintaining friendships or engage in sensory seeking behaviors. These identification challenges indicate a need to explore differences and similarities between ASD and common co-occurring NDDs to inform identification practices.

**EF Associated with ASD and Other NDDs**

Children with ASD, ID, and ADHD often have notable EF difficulties (Henry et al., 2010; Craig et al., 2016). Due to the complexity of developmental disorders and similarities in symptom presentation, overlapping and differing EF strengths and weaknesses are expected across NDDs. Deficits in vigilance (Corbett et al., 2009), inhibition (Corbett et al., 2009; Hill, 2004), cognitive flexibility and shifting (Corbett et al., 2009; Hill, 2004), planning (Hill, 2004), and working memory (Corbett et al., 2009) are consistent with childhood ASD. Children with ASD and ADHD similarly have EF deficits in inhibition, planning, and verbal working memory (Pitzianti et al., 2016).
Comparing children with ASD and ADHD, ASD is associated with significant impairments in planning and flexibility, whereas ADHD is associated with more severe deficits in inhibition and working memory (Sinzig et al., 2008a). Prior studies found that children who have ADHD presented with more deficits in sustained (Sinzig et al., 2008a) and orienting (Tye et al., 2014) attention, whereas children who have ASD have increased difficulties with divided attention (Sinzig et al., 2008a). In comparison to their neurotypical (NT) peers, children with ASD, ADHD, and ASD+ADHD have increased attention difficulties (Craig et al., 2015). Furthermore, children with ADHD and ASD+ADHD exhibit more inattention than children with ASD (Craig et al., 2015). One research study conducted by Dajani et al. (2016), showed that children with ASD+ADHD have more impaired EF than those with ASD and ADHD, but specific areas of EF were not discussed.

Research has limitedly explored how co-occurring ID or ADHD impacts EF skills in children with ASD. EF differences are evident between children with ASD, ID, and ASD+ID. Markedly, more working memory difficulties have been shown in children with ASD+ID compared to children with only ID (Trezise et al., 2014). A study conducted by McClain et al. (2017) indicated that children with ADHD and ASD+ADHD display significantly more inattention than children with ASD+ID and ID. Based on the Behavior Rating Inventory of Executive Functions (BRIEF; Gioia et al., 2000), a study conducted by Panerai et al. (2014) publicized that children with ASD have more global EF, inhibition, emotional control, working memory, planning, and monitoring deficits than children with co-occurring ASD+ID. Notably, shifting appeared to be the only area
of EF that both children with ASD and ASD+ID had significant impairments. The results of this study suggest that children with ASD+ID do not have unique EF deficits.

**Current Study**

Research exploring EF in children with ASD and co-occurring ID or ADHD is emerging. The various assessments available, age restrictions of assessments, as well as different measurements of EF between indirect (e.g., behaviors rating scales) and performance-based assessments, make determining concrete EF differences difficult. By understanding how EF differs across these disorders, clinicians may be better able to differentiate ASD from other NDDs and also to determine a co-occurring ID or ADHD. Furthermore, understanding EF strengths and weaknesses across these NDDs can help to inform targeted interventions for children with these NDDs. We sought to assemble current research and explore unique EF strengths and weaknesses for children with ASD+ID and ASD+ADHD. We also discuss characteristics (e.g., specific assessments used, gender/age/diagnoses of participants, location of studies/authors) associated with all studies included in this review to inform service provisions and future research.

This systematic review was conducted to answer the following research questions:
1) What are the relative EF strengths and impairments across children with ASD+ADHD and ASD+ID?; 2) How does a co-occurring diagnosis of ID or ADHD impact EF in children with ASD?; 3) What are the characteristics of commonly used assessments when measuring EF in children with ASD+ID and ASD+ADHD?; and, 4) Are there differences in how EF presents between performance-based and indirect measures of EF in this population?
Method

Article Identification

We conducted a systematic article search in PsychINFO, PubMED, and Medline databases with no date restriction. Due to the considerably high number of articles (e.g., 2000+) resulting from a search of the articles’ entire text, the search was restricted to the articles’ titles and abstracts. Considering the articles sought for this review were to be focused on EF, theoretically searching only the titles and abstracts is sufficient. Search terms were grouped by diagnosis (i.e., ASD+ID, ASD+ADHD), child classification, and EF. For ASD the following search terms were used: "autis*" OR "autism spectrum disorder" OR "Asperger*" OR "pervasive developmental disorder" OR "PDD NOS" OR "ASD". For ID the following search terms were used: "intellectual disability" OR "intellectual develop* disorder" OR "low function*" OR "low IQ" OR "low intellectual quotient" OR "low intelligence quotient" OR "mental retardation". For ADHD the following search terms were used: “ADHD” OR “attention deficit hyperactivity disorder” OR “ADD”. For the child classification, the following search terms were used: "child*" OR "teen*" OR "school age*" "school-age*" OR "adolescen*" OR "youth". For the area of EF the following search terms were used: "executive dysfunction" OR "executive function*" OR "inhibit*" OR "plan*" OR "organiz*" OR "initiat*" OR "working memory" OR "flexibil*" OR "switch*" OR "concept formation" OR "attention" OR "problem solve" OR "emotion control" OR "self monitor*".

A systematic search in PsychINFO (1,085 articles), PubMED (1,522 articles), and Medline (145 articles) databases resulted in an initial 2,752 articles. We used Zotero (Ahmed & Dhubaib, 2011) to determine the total number of articles, with duplicates
removed, yielded from the initial database searches. Zotero results yielded 1,710 unique articles. Each article’s abstract was screened for the inclusion of an ASD+ADHD and/or ASD+ID diagnostic group, the evaluation of EF, and child/adolescent participants. Additionally, only articles offered in English were included. Sixty-nine articles passed the abstract screening process. A full-article review was conducted to determine final inclusion based on the following criteria: 1) the examination of EF, 2) one group examined must be classified as having a diagnosis of ASD+ADHD or ASD+ID, and 3) all participants must be children/adolescents (under the age of 22 years). Studies were excluded from analyses if they: 1) did not meet the previous inclusion criteria, 2) did not have a formal diagnosis (e.g., elevated ADHD symptoms rather than a diagnosis of ADHD), and/or 3) were intervention studies. Following the full article review, 20 articles met the inclusion criteria. The other 49 articles were removed for the following reasons: 1) elevated symptoms of ASD or ADHD rather than a formal diagnosis (k=30), 2) intervention study (k=7), 3) a co-occurring (ASD+ADHD or ASD+ID) group was not examined (k=6), 4) not clearly examining EF (k=4), 5) EF was used as a moderator rather than being examined as a dependent variable (k=1), and 6) ASD+ID was not analyzed separately from ASD (k=1). The references of these articles (k=20) were then examined as a part of an ancestral search. Four additional articles met the criteria for this review. Overall, a total of 24 articles examining ASD+ADHD (k=14), ASD+ID (k=9), and ASD+ID/ASD+ADHD (k=1) met inclusion criteria and were further analyzed. Two of the articles (i.e., Bebko & Ricciuti, 2000, Kado et al., 2020) each reported on two separate sets of participants and analyses. Therefore, a total of 26 studies resulted from the 24 articles meeting the inclusion criteria. See Figure 1 for a flow diagram of the
article identification process. The flow diagram was adopted and adapted from Moher et al. (2009).

**Interrater Coder Training**

Three graduate student researchers and one undergraduate student researcher served as coders. Prior to coding the identified articles, all coders participated in two trainings. The first training consisted of coding four practice articles and the second training involved collaboratively coding an article that met inclusion criteria. To familiarize coders with study procedures, they were asked to review and complete the REDCap data entry form (see the coding process below; Harris et al., 2009) on four practice articles (i.e., Yerys et al., 2013; de Vries & Geurts, 2014; Lyall et al., 2017; Rosello et al., 2018). Practice articles were selected because they were content-relevant but did not meet full inclusion criteria to be included in the current study. Students completed practice articles independently; they then met to discuss and address discrepancies as well as questions and concerns. The student researchers then participated in a second training session where they collaboratively coded an article included in this review (i.e., McClain et al., 2017) to ensure that coding methods were consistent and well understood.

**Coding Process of Identified Articles**

Student researchers were divided into two groups of two coders. The first group was randomly assigned to code 11 articles (i.e., Buhler et al., 2011; Dajani et al., 2016; DiQuattro, 2013; Hoffmann et al., 2016; Hwang-Gu et al., 2019; Kado et al., 2020\(^2\);

\(^2\) Kade et al., 2020 was coded twice based on the authors’ reports of two separate age groups.
Lundervold et al., 2012; Ng et al., 2019; Pitzianti et al., 2016; Saito et al., 2019; Schiers & Timmers, 2009) and the second group was randomly assigned to code 12 other articles (i.e., Bebko & Ricciuti, 20003; Cheung et al., 2010; Han, 20104; Reed et al., 2011; Han et al., 2013; Craig et al., 2015; Panerai et al., 2014; Trezise et al., 2014; Shahabuddin, 2015; Colombi & Ghaziuddin, 2017; Han & Chan, 2017; Tsermentseli et al., 2018). Student researchers independently completed a REDCap data entry form for each assigned article. Student researchers completed their articles independently and communicated with the first author if clarification was needed. Each group had two coders resulting in all articles being double-coded. REDCap was specifically used in this study due to its ability to double-code articles and identify discrepancies between those double-coded entries.

The REDCap data entry form used to code each article was designed by the first author and consisted of identifying, demographic, and EF information (Appendix B). Identifying information consisted of the first author’s last name, the year the article was published, and the journal it was published in. Demographic information gathered data on the following areas: sample diagnostic groups analyzed (i.e., ASD+ADHD, ASD+ID, ASD5, ADHD, ID, NT, other), sample nationality, sample size, sample sex, sample age, author location, and sample cognitive abilities (average and range) for the total number of participants included in the study as well as for each diagnostic group identified. Of note, although other diagnostic groups (e.g., down syndrome, internalizing disorders, NT) were described in the studies we will only report data on participants from primary diagnostic

3 Bebko & Ricciuti, 2000 was coded twice based on the authors’ separate reports of “Experiment 1” and “Experiment 2”.
4 Of note, Han et al., 2010 is a multi-part dissertation. Only chapter 2 of the dissertation was coded because the other chapters were either published in a peer reviewed journal or did not meet inclusion criteria.
5 “ASD” is being defined as ASD only when ADHD and ID are not co-occurring.
groups (i.e., ASD+ADHD, ASD+ID) and comparison groups (i.e., ASD, ADHD, ID) inherent to our research questions. Student researchers also reported the purpose of the article, the research questions, and the abstract in the demographic information section. Lastly, within the EF information section, all areas of EF analyzed in the article were reported as well as specific information for each measure such as the following: a) type of measure (i.e., performance-based or indirect); b) what wide-range assessment was used and if a subtest/composite/index was analyzed; c) what traditional EF assessment was used and the subtest analyzed; d) who was the respondent if a rating scale was used (i.e., caregivers, teacher, self-report); e) what area of EF the measure analyzed; f) type of standardized score reported (i.e., standard score, scaled score, T-score, Z-score, other, or a standardized score was not reported); g) specific standardized score for each diagnostic group; and, h) if a standardized score was not reported what was the mean and standard deviation for the specific measure for each diagnostic group. Student researchers also coded $p$-values in the EF information section for diagnostic groups that evidenced significant differences.

**Intercoder Reliability**

Once student researchers completed coding their assigned articles, discrepancy meetings were held to discuss inconsistencies among coding pairs. The first and third authors attended all discrepancy meetings. The third author acted as the tiebreaker for pair 1 (first and fourth authors), whereas the first author acted as the tiebreaker for pair 2 (third and fifth). At these meetings, researchers reached 100% agreement on all reported items from an article.
Quality Assessment of Studies

Researchers used the Quality Assessment Tool for Quantitative Studies (Effective Public Health Practice Project, 1998) to assess the quality of the articles included in this systematic review. The first and third authors independently assessed the quality of each article. Any discrepancies were discussed and resolved.

Data Analysis Plan

We utilized Jamovi project (2020), version 1.2, to conduct statistical analyses. Specifically, descriptive statistics were employed to analyze the article and participant demographic information, as well as details of EF. In addition, we used R version 4.0.2 (R Core Team, 2020) in exploratory analyses that transformed standardized scores (i.e., T-scores, standard scores, scaled scores) to Z-scores for studies reporting standardized scores. Due to the varied number of studies and participants as well as the exploratory nature of the analyses, we will not discuss statistical differences between diagnostic group Z-scores.

Results

Table 1 provides study characteristics regarding the 26 studies that describe EF similarities and differences between children with ASD+ADHD and ASD+ID and their respective comparison groups. Specific information provided includes the country where the study was conducted, sample characteristics, the area of EF evaluated, and purpose of the study.

Assessment of Article Quality
The quality of the 24 articles included in this systematic review was evaluated using the Quality Assessment Tool for Quantitative Studies. All articles were classified as either *fair* (i.e., Bebko & Ricciuti, 2000; Colombi & Ghaziuddin, 2017; DiQuattro, 2013; Hoffman et al., 2016; Hwang-Gu et al., 2019; Lundervold et al., 2012; McClain et al., 2017; Ng et al., 2019; Scheirs & Timmers, 2009; Shahabuddin et al., 2015) or *weak* (Buhler et al., 2011; Cheung et al., 2010; Craig et al., 2015; Dajani et al., 2016; Han & Chan, 2017; Han et al., 2010; Han et al., 2013; Kado et al., 2020; Panerai et al., 2014; Pitzianti et al., 2016; Reed et al., 2011; Saito et al., 2019; Trezise et al., 2014; Tsermentseli et al., 2018), whereas none were considered *strong*.

**Characteristics of Participants**

A total of 4,458 children were participants in the 24 journal articles (26 studies). The average age of participants was 10.3 years (*SD*=1.64, range = 4-22 years). There was a total of 3,305 males (78.2%) and 919 females (21.8%) across all studies. Participants had a reported average IQ of 85.7 (*SD*=22.9). A total of 2,266 children were grouped by the following diagnostic categories: ASD (*n*=709), ID (*n*=45), ADHD (*n*=842), ASD+ADHD (*n*=478), and ASD+ID (*n*=192). An additional 2,192 children were in other comparison groups (e.g., ADHD+ID, NT, other psychiatric disorders (OPD), internalizing disorders (IntD), borderline intellectual functioning (BIF), and down syndrome (DS).

Participants who had the following diagnoses were represented in the included studies: ASD (*k*=22), ID (*k*=3), ADHD (*k*=13), ASD+ADHD (*k*=16), and ASD+ID (*k*=11). Of note, not all studies reported age and gender. Across the studies analyzing children with ASD (*k*=21), the average age of participants was 10.3 years (*SD*=1.38), and
the majority were male ($n=594$, 86.5%). Among children in the studies with ID ($k=3$), the majority were male ($n=36$, 80.0%) with an average age of 11.4 years ($SD=3.18$). Studies including children with ADHD ($k=13$) reported an average age of 9.6 years ($SD=1.16$) and included 697 males (82.8%). Of the studies reporting an ASD+ADHD diagnostic group ($k=16$), 390 males (86.1%) and an average age of 10.1 years ($SD=1.31$) were reported. Studies examining children with ASD+ID ($k=11$) reported an average age of 10.9 years ($SD=2.00$) and included 167 males (87.0%).

**Specific Areas of EF Examined**

Investigators of studies in this review measured EF skills across inhibition ($k=10$), planning and organizing ($k=7$), flexibility and shifting ($k=8$), working memory ($k=15$), attention ($k=15$), metacognition ($k=2$), behavior regulation ($k=2$), emotion regulation ($k=1$), and global EF ($k=4$). See Table 1 for more information.

**Procedures to Examine EF**

The studies included in this systematic review used a variety of assessments to measure inhibition (performance-based=8, indirect=1), planning and organizing (performance-based=6, indirect=1), flexibility and shifting (performance-based=5, indirect=0), working memory (performance-based=3, indirect=1), attention (performance-based=2, indirect=6), metacognition (performance-based=0, indirect=1), behavior regulation (performance-based=0, indirect=1), emotional control (performance-based=0, indirect=1), and global EF (performance-based=1, indirect=1). A total of 25 performance-based and 9 indirect measures of EF were used across the 26 studies. The number of performance-based and indirect measures include 1) different editions of the
same assessment but exclude individual subscales of assessments and 2) when authors combined scores from multiple assessments to create a scale.

Common performance-based measures included various versions of the Go/No Go Task (used to measure inhibition in 6 studies), a tower test (used to measure planning and organizing in 6 studies), a trails test (used to measure flexibility and shifting in 4 studies), a card sorting test (used to measure flexibility and shifting in 4 studies), the Wechsler Intellectual Scale for Children (WISC; various editions) working memory index and subscales (used to measure working memory in 6 studies), and a continuous performance test (used to measure attention in 5 studies). The most popular indirect measures of EF were the Behavior Rating Inventory of Executive Functions (parent and teacher versions), the Conners Rating Scales for parents (CPRS) and teachers (CTRS), and the Swanson, Nolan, and Pelham, version IV (SNAP-IV). The BRIEF, both parent and teacher versions, was used to measure inhibition, planning and organizing, working memory, metacognition, behavior regulation, and global EF in 3 studies (parent version = 2 studies, teacher version = 1 study). To measure attention, the CPRS was used in 4 studies and the CTRS was used in 2 studies. The SNAP-IV was utilized in 3 studies to measure attention. See Table 2 for more details regarding the various measures of EF used across the studies.

**EF Similarities and Differences**

The results of EF similarities and differences between ASD+ADHD and ASD+ID and their respective comparison groups pertain to inhibition, planning and organizing, flexibility and shifting, working memory, attention, metacognition, behavior regulation, and global EF. Results for each area of EF will be discussed in terms of performance-
based and indirect measurements of EF. See Table 3 for details regarding significant differences for each study.

**Inhibition**

*Performance-based Assessment Results*

**ASD+ADHD.** Three studies reported that children with ASD+ADHD and ADHD do not show remarkable differences in inhibition skills (DiQuattro, 2013; Pitzianti et al., 2016; Saito et al., 2019). In addition, DiQuattro (2013) found no inhibition skill differences between ASD, ADHD, and ASD+ADHD. Two studies detected no differences between children with ASD and ASD+ADHD (DiQuattro, 2013; Kado et al., 2020). One study found that the ASD group has more elevated inhibition deficits than the ASD+ADHD and ADHD groups (Buher et al., 2011).

**ASD+ID.** Three studies found that children with ASD+ID have more elevated inhibition deficits than children with ASD (Han & Chan, 2017; Han et al., 2013; Panerai et al., 2014). Three studies reported that ASD+ID and ASD groups show no significant differences in inhibition skills (Han & Chan, 2017; Han et al., 2010; Panerai et al., 2014).

*Indirect Assessment Results*

**ASD+ADHD.** One study identified increased inhibition deficits in children with ASD+ADHD compared to children with ADHD (DiQuattro, 2013).

**ASD+ID.** No studies using indirect measures of EF examined inhibition skills among children with ASD+ID.

**Planning and Organizing**

*Performance-based Assessment Results*
**ASD+ADHD.** One study found that both ASD+ADHD and ASD diagnostic groups are associated with more planning and organizing impairments than the ADHD diagnostic group (Pitzianti et al., 2016). In contrast, three additional studies reported that ASD+ADHD and ASD do not significantly differ in planning and organizing skills (Colombi & Ghaziuddin, 2017; DiQuattro, 2013; Pitzianti et al., 2016). One study indicated that children with ASD+ADHD display more elevated planning and organizing impairments than children with ASD (Pitzianti et al., 2016). Two studies reported no statistical differences in planning and organizing skills between ASD+ADHD and ADHD diagnostic groups, nor between ADHD and ASD diagnostic groups (Pitzianti et al., 2016; DiQuattro, 2013). Furthermore, one study found no differences between children with ASD, ADHD, and ASD+ADHD (DiQuattro, 2013).

**ASD+ID.** Three studies found that children with ASD+ID exhibited more severe deficits in planning and organizing than children with ASD (Han & Chan, 2017; Han et al., 2010; Han et al., 2013). Panerai et al. (2014) found that a diagnosis of ASD+ID was associated with more severe planning and organizing difficulties than a diagnosis of ID.

*Indirect Assessment Results*

**ASD+ADHD.** One study using an indirect assessment of EF found that children with ASD, ADHD, and ASD+ADHD did not differ in their planning and organizing skills (DiQuattro et al., 2013).

**ASD+ID.** No studies investigated the differences in planning and organizing skills using an indirect measure of EF among children with ASD+ID.

*Flexibility and Shifting*

*Performance-based Assessment Results*
**ASD+ADHD.** Only two studies examined flexibility and shifting in children with ASD+ADHD. Kado et al. (2020) investigated differences in flexibility and shifting skills among children with ASD and ASD+ADHD. The authors used multiple assessments, including various subscales of the same assessment, to measure flexibility and shifting which resulted in inconsistent findings – see Table 2 for specific assessments and subscales. Results from one direct measure show no differences in flexibility and shifting among ASD and ASD+ADHD. Results from a different direct measure suggested that ASD and ASD+ADHD diagnostic groups do not differ. Lastly, another measure resulted in significant differences between children with ASD and children with ASD+ADHD, with children with ASD showing greater impairments. The latter finding was also supported by a study conducted by Colombi and Ghaziuddin (2017).

**ASD+ID.** Three studies reported that children with ASD+ID have more severe impairments with flexibility and shifting than children with ASD (Han & Chan, 2017; Han et al., 2010; Han et al., 2013). One study found that a diagnosis of ASD+ID results in more flexibility and shifting difficulties than a diagnosis of ID (Panerai et al., 2014).

*Indirect Assessment Results*

There were no studies that examined flexibility and shifting using an indirect measure of EF with either children with ASD+ADHD or ASD+ID.

*Working Memory*

*Performance-based Assessment Results*

**ASD+ADHD.** One study reported that a diagnosis of ASD+ADHD is associated with more working memory deficits than a diagnosis of ASD (Colombi & Ghaziuddin, 2017). In contrast, 3 studies found no significant differences in working memory skills...
between children with ASD+ADHD and children with ASD (DiQuattro, 2013; Ng et al., 2019; Pitzianti et al., 2016). Furthermore, 2 studies found no differences in working memory skills between ASD+ADHD, ASD, and ADHD diagnostic groups (DiQuattro, 2013; Ng et al., 2019). DiQuattro (2013) assessed for working memory using multiple assessment tools which resulted in differing results – see Table 2 for specific assessments and subscales. Specifically, although DiQuattro (2013) found that ASD+ADHD did not differ from ADHD using one assessment, another assessment indicated that children with ASD+ADHD had more working memory impairments than children with ADHD. Conversely, another study reported that children with ADHD displayed more working memory difficulties than ASD+ADHD and ASD comparison groups (Pitzianti et al., 2016).

**ASD+ID.** Trezise et al. (2014) used multiple working memory assessments to determine differences in working memory skills among children with ASD+ID – see Table 2 for specific assessments and subscales. One assessment detected more working memory difficulties among children with ASD+ID as compared to children with ID. Another measurement of working memory detected no differences between children with ASD+ID and ID. Cheung et al. (2010) utilized multiple measures of working memory and found differing results across the various measures – see Table 2 for specific assessments and subscales. Specifically, with one assessment the research team detected no differences in working memory skills between ASD+ID and ASD.

*Indirect Assessment Results*
**ASD+ADHD.** One study comparing working memory skills using an indirect measure of EF showed that ASD+ADHD, ASD, and ADHD diagnostic groups did not significantly differ (DiQuattro, 2013).

**ASD+ID.** Children with ASD+ID have not been used in a study investigating working memory impairments using an indirect measure of EF.

**Attention**

*Performance-based Assessment Results*

**ASD+ADHD.** Two studies identified more attention deficits among children with ASD+ADHD than among their ASD peers (Hwang-Gu et al., 2019; Shahabuddin 2015). Kado et al. (2020) used multiple assessments of attention and found contradicting results across the multiple measures – see Table 2 for specific assessments and subscales. The research team found that children with ASD have worsened attention than children with ASD+ADHD, whereas another assessment resulted in no significant attention differences between ASD and ASD+ADHD diagnostic groups. Two studies indicated that ASD+ADHD and ADHD diagnostic groups do not differ in attention problems (Hwang-Gu et al., 2019; Ng et al., 2019). Conversely, one study found that ADHD is associated with more attention impairments than a diagnosis of ASD+ADHD (Hwang-Gu et al., 2019). Two studies contradict the previous finding by indicating that children with ASD+ADHD display more attention problems than children with ADHD (Saito et al., 2019; Shahabuddin, 2015). One study detected more attention difficulties among children with ADHD than children with ASD (Hwang-Gu et al., 2019). In contrast, another study indicated that the ASD diagnostic group exhibited more attention impairments than the ADHD comparison group (Shahabuddin, 2015). An additional 3 studies found no
significant differences between ADHD and ASD diagnostic groups in terms of attention problems (Hwang-Gu et al., 2019; Ng et al., 2019; Shahabuddin, 2015).

**ASD+ID.** There were no studies that explored attention skills in children with ID using a performance-based measure.

*Indirect Assessment Results*

**ASD+ADHD.** Five studies found that children with ASD+ADHD exhibit worsened attention than children with ASD (Colombi & Ghaziuddin, 2017; Craig et al., 2015; Hoffmann et al., 2016; Hwang-Gu et al., 2019; Shahabuddin, 2015). Three studies indicated that children with ASD+ADHD have more significant attention problems than children with ADHD (Hoffmann et al., 2016; Hwang-Gu et al., 2019; Shahabuddin, 2015). Three studies identified no attention differences between ADHD and ASD diagnostic groups (Hoffman et al., 2016; McClain et al., 2017; Shahabuddin, 2015). Four studies detected no significant differences between ASD+ADHD and ADHD diagnostic groups (Craig et al., 2015; McClain et al., 2017; Ng et al., 2019; Saito et al., 2019). Two studies reported that ASD, ADHD, and ASD+ADHD diagnostic groups do not differ in their attention skills (McClain et al., 2017; Ng et al., 2019).

**ASD+ID.** One study investigated attention skills in children with ASD+ID using an indirect measure of attention (McClain et al., 2017). Researchers found no attention differences between ASD, ID, and ASD+ID diagnostic groups. In addition, they reported that children with ADHD have more attention impairments than children with ASD+ID.

*Metacognition*

*Performance-based Assessment Results*
There were no studies that assessed metacognition using a performance-based assessment among children with ASD+ID or ASD+ADHD. However, there are no known performance-based measures of metacognition.

Indirect Assessment Results

**ASD+ADHD.** No studies have investigated differences in metacognition skills between children with ASD+ADHD and comparison groups.

**ASD+ID.** One study investigated metacognition skills among children with ASD+ID (Panerai et al., 2014). The researchers reported no significant differences between children with ID and ASD+ID.

Behavior Regulation

Performance-based Assessment Results

Studies have not used performance-based assessments to explore behavior regulation in children with ASD+ADHD and ASD+ID. Similar to metacognition, there is no known performance-based measure of behavior regulation.

Indirect Assessment Results

**ASD+ADHD.** Behavior regulation differences between children with ASD+ADHD and comparison groups have not been assessed using an indirect measure.

**ASD+ID.** One study found more behavior regulation difficulties in children with ASD+ID compared to their peers with ID (Panerai et al., 2014).

Global EF

Performance-based Assessment Results

**ASD+ADHD.** No studies examined global EF among children with ASD+ADHD using a performance-based assessment.
ASD+ID. Two studies found that ASD+ID is associated with more global EF deficits than children with ASD (Han & Chan, 2017; Han et al., 2013).

Indirect Assessment Results

ASD+ADHD. Global EF skills have not been investigated among children with ASD+ADHD using an indirect measure of EF.

ASD+ID. Regarding global EF skills, Panerai et al. (2014) found that children with ID and ASD+ID do not significantly differ.

Standardized Scores of EF

Among the 26 studies analyzed in this systematic review, 12 studies reported standardized scores (i.e., Colombi & Ghaziddin, 2017; Craig et al., 2015; Dajani et al., 2016; DiQuattro, 2013; Hoffman et al., 2016; McClain et al., 2017; Ng et al., 2019; Panerai et al., 2014; Pitzianti et al., 2014; Scheirs & Timmers, 2009; Shahabuddin, 2015; Tsermentseli et al., 2018). Within the 12 studies, a total of 9 assessments (various versions and subscales) were used to assess EF skills (i.e., working memory, inhibition, behavior regulation, planning and organizing, attention, emotional control, metacognition, and flexibility and shifting). All standardized scores reported (i.e., T-score, Standard Score, Scaled Score) were converted to Z-scores to ensure that the scores were comparable. The mean Z-scores for each area of EF, grouped by diagnostic group, are represented numerically and visually in Table 4 and Figure 2.

Z-scores have a mean of 0 and a standard deviation of 1. Significant impairments are defined when a specified Z-score is higher than 1 standard deviation above the mean. For the purposes of this study, Standard and Scaled Scores were reverse-scored so that a higher Z-score signifies a higher level of impairment. We found that in these studies,
children with ASD have notable impairments in attention and metacognition. The only area of EF that children with ADHD displayed significant impairments was attention. Similarly, ID was also associated with significant impairments in attention and metacognition. Both co-occurring diagnostic groups exhibited more significant impairments across a greater range of EF skills than their clinical comparison groups. ASD+ADHD was associated with significant impairments in working memory, inhibition, planning and organizing, and attention. ASD+ID was also linked to significant impairments in inhibition and attention, but also behavior regulation, emotional control, metacognition, and flexibility and shifting.

Comparing EF Across Diagnostic Groups

Working memory was examined within ASD, ADHD, and ASD+ADHD diagnostic groups. ASD+ADHD appears to have worsened working memory abilities, whereas ASD and ADHD groups do not differ greatly. Inhibition skills were measured in children with ASD, ADHD, ASD+ADHD, and ASD+ID. Inhibition skills are more impaired in children with ASD+ID, followed by those with ASD+ADHD. ASD and ADHD do not differ considerably in their inhibition skills but are less impaired than children with ASD+ID and ASD+ADHD. Behavior regulation was assessed among ASD, ID, and ASD+ID. The results indicated that children with ASD+ID display remarkably more impairments followed by children with ASD. Children with ID exhibit more developed behavior regulation skills than children with ASD and ASD+ID.

Children with ASD, ADHD, and ASD+ADHD were examined for impairments in planning and organizing. The three diagnostic groups do not appear to differ greatly in their planning and organizing skills. However, ASD+ADHD exhibit more impairments,
followed by ASD and ADHD respectively. Attention was assessed among all diagnostic groups. The results indicate that the ASD, ADHD, ASD+ADHD, and ASD+ID groups do not greatly differ. However, children with ASD+ADHD and ADHD appear to have the most impaired attention, followed by children with ID, ASD+ID, and ASD, respectively. ASD, ID, and ASD+ID diagnostic groups’ metacognition skills were assessed. Children with ID have considerably more metacognition deficits, followed by children with ASD and ASD+ID. Children with ASD have comparable metacognitive skills to children with ASD+ID. Emotional control as well as flexibility and shifting skills were only assessed in children with ASD+ID.

**Relative Strengths and Weaknesses within Diagnostic Groups**

Working memory, inhibition, behavior regulation, planning and organizing, attention, and metacognition skills were assessed among children with ASD. Children with ASD present with a relative weakness in metacognitive skills and strength in inhibition. Specific areas of EF that were measured in children with ADHD included working memory, inhibition, planning and organizing, and attention. ADHD was associated with a relative weakness in attention and a strength with inhibition. Behavior regulation, attention, and metacognition were assessed among children with ID. Children with ID show a considerable weakness with metacognition and a relative strength with behavior regulation. EF skills were measured in children with ASD+ADHD by assessing for impairments in working memory, inhibition, planning and organizing, and attention. Children with ASD+ADHD display consistent impairments across these four areas of EF, with a slight relative weakness with attention. Inhibition, behavior regulation, attention, emotional control, metacognition, and flexibility and shifting were areas of EF assessed
among children with ASD+ID. A co-occurring diagnosis of ASD+ID is related to a relative strength with attention and weaknesses with metacognition as well as flexibility and shifting.

**Discussion**

We identified 26 studies in 24 articles for this systematic review that examined EF skills among children with ASD+ADHD \((k=16, n=478)\) and ASD+ID \((k=11, n=192)\). EF areas examined spanned inhibition, planning and organizing, flexibility and shifting, working memory, attention, metacognition, behavior regulation, emotion regulation, and global EF.

**EF Similarities and Differences**

When examining EF skill similarities and differences between children with ASD+ADHD and ASD+ID and their respective comparison groups, results were often inconsistent. The contradictory findings may be due to differences in sample size or participant characteristics such as age, symptomology severity, as well as intellectual and adaptive functioning. Variability in EF assessment methods may also contribute to these differences as many of the studies used different EF measures. Although different measures theoretically assess the same EF construct, there may be measurement differences or invariance. Nonetheless, patterns of similarities and differences emerged in this systematic review. Due to the inconsistencies and limited research, the results and inferences should be interpreted with caution and as preliminary.

**Co-occurring ASD and ADHD**

*Performance-based Assessments*
Using performance-based measures, Children with ASD+ADHD may display unique EF strengths and weaknesses relative to children with ASD and ADHD. Regarding inhibition, most studies show that children with ASD+ADHD exhibit similar skills compared to children with ASD (DiQuattro, 2013; Kado et al., 2020) and ADHD (DiQuattro, 2013; Pitzianti et al., 2016; Saito et al., 2019). When considering planning and organizing skills, children with ASD+ADHD perform comparably to children with ASD (Colombi & Ghaziuddin, 2017; DiQuattro, 2013; Pitzianti et al., 2016) and ADHD (Pitzianti et al., 2016; DiQuattro, 2013). Flexibility and shifting skills are shown to be more impaired in children with ASD than in children with ASD+ADHD (Colombi & Ghaziuddin, 2017; Kado et al., 2020). Most studies show that working memory skills in children with ASD+ADHD are comparable to their peers with ASD and ADHD (DiQuattro, 2013; Ng et al., 2019; Pitzianti et al., 2016). There is considerable variability in attention skills, but children with ASD+ADHD tend to have more attention difficulties than children with ASD (Hwang-Gu et al., 2019; Shahabuddin 2015). However, studies are divided when comparing children with ASD+ADHD to children with ADHD; some studies show no differences between the two diagnostic groups (Hwang-Gu et al., 2019; Ng et al., 2019) whereas others show more attention impairments among children with ASD+ADHD compared to children with ADHD (Saito et al., 2019; Shahabuddin, 2015).

**Indirect Assessments**

Three areas of EF – inhibition, planning and organizing, and attention – were investigated with children who have ASD+ADHD using an indirect assessment of EF. In contrast to performance-based measures, children with ASD+ADHD present with poorer inhibition skills than their peers with ADHD (DiQuattro, 2013). In terms of planning and
organizing skills, ASD+ADHD did not considerably differ from children with ASD and ADHD (DiQuattro et al., 2013). Similar to the results of the performance-based assessments, children with ASD+ADHD have considerably more inattention than children with ASD (Colombi & Ghaziuddin, 2017; Craig et al., 2015; Hoffmann et al., 2016; Hwang-Gu et al., 2019; Shahabuddin, 2015). In addition, there were inconsistencies in attention skills when comparing children with ASD+ADHD and ADHD, with some studies finding no differences (Hoffmann et al., 2016; Hwang-Gu et al., 2019; Shahabuddin, 2015) and others finding that children with ASD+ADHD exhibit more attention challenges than their peers with ADHD (Craig et al., 2015; McClain et al., 2017; Ng et al., 2019; Saito et al., 2019).

**Co-occurring ASD and ID**

*Performance-based Assessments*

Inhibition skill differences between children with ASD+ID when compared to children with ASD and ID, are also inconsistent. Some studies indicate that children with ASD+ID have more inhibition skill deficits compared to their ASD peers (Han & Chan, 2017; Han et al., 2013; Panerai et al., 2014). Whereas other studies report that there are no inhibition skill differences between ASD+ID and ASD (Han & Chan, 2017; Han et al., 2010; Panerai et al., 2014). In terms of planning and organizing, children with ASD+ID exhibit more impairments than their ASD (Han & Chan, 2017; Han et al., 2010; Han et al., 2013) and ID (Panerai et al., 2014) counterparts. Similarly, when evaluating flexibility and shifting, children with ASD+ID have more impairments than children with ASD (Han & Chan, 2017; Han et al., 2010; Han et al., 2013), ID (Panerai et al., 2014), and NT (Han & Chan, 2017; Han et al., 2010). There do not appear to be unique working
memory impairments in children with ASD+ID as compared to children with ASD (Cheung et al., 2010). When looking at global EF, children with ASD+ID show more impairments than children with ASD (Han & Chan, 2017; Han et al., 2013).

*Indirect Assessments*

Indirect assessments of EF show similarities and differences between children with ASD+ID and comparison groups in attention, metacognition, behavior regulation, and global EF. Children with ASD+ID do not show unique attention impairments as compared to children with ASD and ID; however, children with ADHD may display more attention difficulties than children with ASD+ID (McClain et al., 2017). Although children with ASD+ID seem to exhibit more behavior regulation difficulties than children with ID, this does not hold for metacognition skills (Panerai et al., 2014).

*Performance-based versus Indirect Assessments*

Both performance-based and indirect measures of EF were used to investigate inhibition, planning and organizing, flexibility and shifting, and attention skills among children with ASD+ADHD relative to their comparison groups. Results of both performance-based and indirect measures of EF are consistent in terms of planning and organizing as well as attention deficits. However, performance-based and indirect assessments of EF are inconsistent when measuring inhibition as well as flexibility and shifting skills. For children with ASD+ID, there were no areas of EF that were evaluated with both performance-based and indirect measures of EF that also used the same comparison groups. Conflicting findings between performance-based and indirect assessments of EF align with previous research (Miranda et al., 2015; Toplak et al., 2013). This is likely because indirect measures of EF assess how children’s EF manifests
in real-world contexts (Roth et al., 2005) whereas performance-based measures are conducted in highly controlled clinical settings that may not generalize to everyday functioning.

**Standardized Scores of EF**

The results of the standardized scores of EF suggest that children with ASD+ADHD and ASD+ID have poorer EF skills than their ASD counterparts as measured by both performance-based and indirect measures. Notably, children with ASD and ASD+ID have comparable metacognition and attention skills. Moreover, children with ASD+ADHD display more deficits in the areas of working memory, inhibition, and planning and organizing skills whereas children with ASD+ID exhibit poorer inhibition and behavior regulation impairments. In terms of working memory, ASD and ADHD diagnostic groups do not greatly differ from each other. However, children with ASD+ADHD may have more difficulties with working memory skills than children with ASD and ADHD.

**Clinical Implications**

Understanding EF similarities and differences between children with ASD+ADHD, ASD+ID, and ASD can inform better assessment techniques for determining a differential or co-occurring diagnosis and aid in the development of targeted intervention strategies. Overall, children with ASD+ADHD and ASD+ID have more severe EF impairments than their peers with ASD. Measuring EF may also help clinicians differentiate children with ASD+ADHD and ASD+ID from children with ASD only. When compared to children with ASD, children with ASD+ADHD exhibit more
difficulties with working memory, inhibition, planning and organizing, as well as attention, whereas children with ASD+ID display more deficits with inhibition and behavior regulation. Further examination of the studies’ reported standardized scores suggests that children with ASD+ADHD display consistent EF impairments with working memory, inhibition, and planning and organizing in addition to a relative weakness with attention. In contrast, children with ASD+ID present with relative strength with attention and weaknesses with metacognition and flexibility/shifting.

Performance-based and indirect assessments of EF skills play distinctive, but valuable roles in evaluations (Toplak et al., 2013). Thus, it is recommended that practitioners use both performance-based and indirect assessments of EF in evaluations. Our results corroborated this notion as we found both types of assessments produce differing results but a unique insight into the EF strengths and weaknesses in children with ASD and co-occurring ADHD and ID. Performance-based measures may be used to examine a child’s ability to efficiently problem solve, whereas indirect measures can evaluate the ability to problem solve and make decisions based on the individual’s unique goals and values (Toplak et al., 2013). Although both performance-based and indirect EF measures may aid clinicians during the diagnostic process, they may consider using indirect measures for education and treatment planning for a more ecologically relevant source of information to directly highlight functioning in specific contexts (e.g., home, school, work).

Although results from our systematic review provide clinical guidance, it has increased utility for school-aged children. Our results highlight the lack of research evaluating EF in early childhood children (< 5 years). Early childhood is a critical
developmental period during which EF skills develop rapidly and are associated with academic readiness skills and positive school outcomes (Blair, 2016; Fitzpatrick et al., 2014). The average age of participants in this review was 10.3 years (range: 4-22 years) with only five studies including participants as young as 4 years. As many of the available EF assessments are developed for older children and adults (e.g., Delis Kaplan Executive Function System [DKEFS; Delis & Kramer, 2001] – 8 years+, Conners Continuous Performance Test Third Edition [CCPT-3; Conners, 2014] – 8 years+), it is not surprising that most published research does not include children in early childhood. With that said, assessments do exist that are validated with young children (e.g., BRIEF-Preschool Version – 2-5 years [Gioia et al., 2003]; Developmental NEuroPSYchological Assessment, Second Edition [NEPSY-II; Korkman & Kemp, 2007] – 3 years+).

Although sparse, research is beginning to emerge that explores EF in preschool-age populations respective to NDDs (e.g., Blair, 2016; Fitzpatrick et al., 2014; McClain et al., 2022). The limited research for young children restricts the generalizability of clinical implications to young children, which is problematic considering they are in a crucial developmental period that requires targeted interventions. Early intervention is especially important for children with ASD and NDDS (Debodiance et al. 2017; Hampton and Kaiser 2016; Peters-Scheffer et al. 2011; Reichow 2012) therefore identifying them at a young age is critical. Knowing how and if EF can help in that process as well as its utility to inform treatment is important.

Limitations and Future Research

One limitation to this study is the limited research available and the methodological variability across studies as researchers employed many different
performance-based and indirect assessments. Furthermore, EF is broad and encompasses various skills. Considering that a variety of studies examined multiple areas of EF along with using multiple measures to assess a single area of EF, the number of studies evaluating EF constructs is sparse. Interpretations using only a few studies may be biased and should be further explored. Our ability to compare EF strengths and deficits across diagnostic groups was further complicated by the varying comparison groups used in each study. Overall, this systematic review's inferences about EF skills should be considered preliminary. Further research on this topic is sorely needed to better understand EF strengths and weaknesses in children with ASD+ADHD and ASD+ID.

Another limitation is the broad age range of participants in the included studies. EF skills change as children age and daily demands increase (Jurado & Rosselli, 2007). As this systematic review includes studies focusing on childhood through adolescence due to the limited research examining EF with children, we cannot discuss the trajectory of EF skills in children with ASD, ASD+ADHD, and ASD+ID. Future research examining EF skills should focus on targeted age groups (e.g., early childhood, middle childhood, adolescence) and examine how EF changes as individuals age and develop. Future reviews should focus on specific ages and developmental periods as more research emerges.

Another limitation is regarding the interpretation of the standardized score analyses. While informative and suggestive of EF profile presentations across diagnostic groups, not all areas of EF were analyzed across all diagnostic groups and a different number of studies and respective participants contributed to the mean Z-scores. Consequently, results may be biased and not fully representative of the diagnostic
groups’ skills. Additionally, no diagnostic group was assessed across all areas of EF which make it difficult to interpret relative strengths and weaknesses in EF skills across all diagnostic groups in addition to accurately comparing diagnostic groups within one area of EF. Due to this limitation, we did not use statistical comparisons to analyze the mean Z-scores and instead descriptively discussed possible differences. In addition, standardized assessments and scores are recommended to be used in future research to ensure appropriate comparisons with other studies and across measures. When more specific research has been completed, future research should conduct a meta-analysis to thoroughly investigate strengths and weaknesses in EF among children with ASD+ADHD and ASD+ID. Further research should use standardized assessments to measure EF skills across multiple diagnostic groups to add to the literature regarding relative EF strengths and weaknesses within diagnostic groups.

Inconsistent results emerged across many of the areas of EF (e.g., attention, working memory, inhibition) in this review. Researchers have developed several EF models that explain how many of these individual skills overlap and comprise larger composites (e.g., Barkley, 1997; Miyake et al., 2000; Lezak, 2012). For example, Miyake et al. (2000) developed a three-factor model of EF: 1) updating (the ability to update and monitor information); 2) shifting (the ability to cognitively shift attention between tasks efficiently); and 3) inhibition (the ability to deliberately stop an automatic response). Additionally, the BRIEF-2 (Gioia et al., 2015) follows a model of EF that loads the individual areas of EF onto specific domains: 1) behavior regulation (ability to regulate and monitor behavior), 2) emotion regulation (ability to regulate emotional responses and adjust to changes in the environment), 3) cognitive regulation (ability to problem solve as
well as control and manage cognitive processes), and 4) global EF (combination of the previous domains and summary of EF skills). Due to inconsistencies and overlap in areas of EF, further research should explore how clinical diagnoses of ASD, ASD+ID, and ASD+ADHD differ in terms of larger EF domains rather than in individual areas of EF.

Another limitation of the study is related to the quality of the included articles. None of the articles in this systematic review were considered strong based on the quality check measure. Instead, more than half of the articles (k=14) demonstrated weak quality. The poor quality is expected due to the measure rating experimental and intervention design studies as having higher quality and non-experimental designs (e.g., cross-sectional) as having lower quality. Considering the focus of this systematic review is to evaluate present levels of EF, it is not surprising that all included studies were cross-sectional designs and thus non-experimental. This meant that all the articles lost quality points on multiple domains of quality (e.g., study design, blinding) reducing the overall quality. The quality of the articles suggests that the inferences made in this systematic review should be cautiously interpreted.

**Conclusion**

ASD has variable and complex symptomology that can make accurately identifying and providing appropriate services to children in this population difficult. These tasks are further complicated when an accompanying NDD, particularly ADHD or ID is present considering the symptom overlap in these disorders (Grzadzinski et al., 2010; Lecavalier et al., 2011; Mayes et al., 2012; Staikova et al., 2013). In order for children to be appropriately diagnosed and receive targeted interventions, techniques
must be available to clinicians to assess various areas of functioning, including EF. Many children with ASD, ADHD, and ID exhibit EF impairments (Henry et al., 2010; Craig et al., 2016), but EF profiles are not clearly understood in children with co-occurring ASD+ADHD and ASD+ID. This review sought to systematically gather studies that evaluated EF in children with ASD+ADHD and ASD+ID to determine how their EF presentations differed from ASD. Overall, this systematic review revealed several informative findings and a need for further research in this area. Although results are somewhat inconsistent across studies, likely due to methodological variability, children with ASD+ADHD and ASD+ID appear to present with relative EF strengths and weaknesses when compared to children with ASD. Furthermore, performance-based and indirect assessments of EF have incongruencies in this population that are likely due to measuring different constructs of EF (Toplak et al., 2013). Although the current findings guide the use of EF measurement in the identification and service provision of children with ASD+ADHD and ASD+ID, further research needs to investigate EF in this population using both performance-based and indirect assessments as well as across various areas of EF and age groups to more comprehensively understand EF respective to these co-occurring groups.
References

*denotes articles included in the systematic review


*Han, Y. M. (2010). *Altered Immune Function Associated with Neurophysiologic Abnormalities and Executive Function Deficits in Children with Autism Spectrum Disorders*. The Chinese University of Hong Kong (Hong Kong).


examined by the Wisconsin card sorting test: Analysis by age-related differences.

*Brain & Development, 42, 113-120.*


<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Number of participants (males)</th>
<th>Diagnostic groups</th>
<th>Average age (age range)</th>
<th>EF evaluated</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bebko &amp; Ricciuti, 2000^2 - 1</td>
<td>Canada</td>
<td>33 (33)</td>
<td>ASD (11), ASD+ID (11), NT (11)</td>
<td>9.08 (4–17)</td>
<td>Working Memory</td>
<td>^The study was designed to examine rehearsal strategy use with children with autism. Specifically, the authors were interested in whether or not memory strategies would be generated spontaneously, the effects of strategy use on performance, and the role of task conditions in eliciting greater strategy use.</td>
</tr>
<tr>
<td>Buhler et al., 2011</td>
<td>Germany</td>
<td>222 (208)</td>
<td>ASD (86), ADHD (84), ASD+ADHD (52)</td>
<td>10.12 (4-22)</td>
<td>Inhibition</td>
<td>The study analyzed the variables inhibitory control and theory of mind, including a developmental aspect in the case of the latter, to differentiate between the disorders. The study aimed to investigate the verbal memory skills of high- and low-functioning children with autism using the information processing model.</td>
</tr>
<tr>
<td>Cheung et al., 2010</td>
<td>China</td>
<td>60 (51)</td>
<td>ASD (22), ASD+ID (16), NT (22)</td>
<td>10.27 (NR)</td>
<td>Working Memory</td>
<td></td>
</tr>
<tr>
<td>Source</td>
<td>Location</td>
<td>Sample Size</td>
<td>diagonally diagnosed features</td>
<td>Performance domains</td>
<td>Study aim</td>
<td></td>
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<tr>
<td>Craig et al., 2015</td>
<td>Italy</td>
<td>181 (151)</td>
<td>ASD (43), ADHD (51), ASD+ADHD (31), NT (56)</td>
<td>Attention</td>
<td>The aim of the study was to evaluate the common or differentiating clinical features between ASD and ADHD in order to identify possible different phenotypes that could have a clinical value.</td>
<td></td>
</tr>
<tr>
<td>Colombi &amp; Ghaziuddin, 2017</td>
<td>United States of America</td>
<td>47 (NA)</td>
<td>ASD (22), ASD+ADHD (25)</td>
<td>Planning, Cognitive Flexibility/Shifting, Working Memory, Attention</td>
<td>The aim of the study was to extend the work on the neuropsychological profile of individuals with ASD + ADHD and to explore the hypothesis that subjects with ASD + ADHD show higher degrees of impairment in social cognition than those with ASD only. The objective of the study was to identify distinct profiles of EF across NT children and children with ASD and ADHD.</td>
<td></td>
</tr>
<tr>
<td>Dajani et al., 2016</td>
<td>United States of America</td>
<td>321 (252)</td>
<td>ASD (30), ADHD (93), ASD+ADHD (66), NT (128)</td>
<td>Working Memory, Attention</td>
<td>The study examined the EF profile of children diagnosed with ASD+ADHD and compared their performance to the performance of children with a single diagnosis of ADHD and children with a single diagnosis of ASD.</td>
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</tr>
<tr>
<td>DiQuattro, 2013</td>
<td>United States of America</td>
<td>53 (31)</td>
<td>ASD (13), ADHD (27), ASD+ADHD (13)</td>
<td>Inhibition, Planning, Working Memory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Sample Size</td>
<td>Inclusion Criteria</td>
<td>Key Findings</td>
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<tr>
<td>Han &amp; Chan, 2017</td>
<td>China</td>
<td>67 (49)</td>
<td>ASD (19), ASD+ID (19), NT (29)</td>
<td>The present study compared EF between high-functioning (HFA) and low-functioning (LFA) children with NT children and neural in the distributed frontoparietal network.</td>
<td></td>
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</tr>
<tr>
<td>Han et al., 2010</td>
<td>China</td>
<td>66 (49)</td>
<td>ASD (19), ASD+ID (19), NT (28)</td>
<td>The purpose of the study was to examine the relationship between immune functions, EF and neurophysiological activities in children with ASD.</td>
<td></td>
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</tr>
<tr>
<td>Han et al., 2013</td>
<td>China</td>
<td>34 (29)</td>
<td>ASD (17), ASD+ID (17)</td>
<td>This study aimed to examine whether there is an association between the neural connectivity and immunological functions of young children with ASD.</td>
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<td></td>
</tr>
<tr>
<td>Hoffmann et al., 2016</td>
<td>Germany</td>
<td>1800 (1303)</td>
<td>ASD (88), ADHD (337), ASD+ADHD (42), OPD (969), IntD (364)</td>
<td>This study aimed to examine symptom profiles and the usefulness of the CBCL for ASD screening purposes.</td>
<td></td>
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</tr>
<tr>
<td>Study</td>
<td>Location</td>
<td>Sample Size (Sample Size)</td>
<td>ASD (Sample Size), ADHD (Sample Size), ASD+ADHD (Sample Size), NT (Sample Size)</td>
<td>Parameter(s)</td>
<td>Notes</td>
<td></td>
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<tr>
<td>Hwang-Gu et al., 2019</td>
<td>Taiwan</td>
<td>568 (480)</td>
<td>ASD (124), ADHD (98), ASD+ADHD (97), NT (249)</td>
<td>11.47 (8–16)</td>
<td>Attention</td>
<td></td>
</tr>
<tr>
<td>Kado et al., 2020¹ - 1</td>
<td>Japan</td>
<td>82 (61)</td>
<td>ASD (30), ASD+ADHD (22), NT (30)</td>
<td>8.20 (5–9)</td>
<td>Inhibition, Flexibility / Shifting, Working Memory, Attention</td>
<td></td>
</tr>
<tr>
<td>Kado et al., 2020¹ - 2</td>
<td>Japan</td>
<td>99 (89)</td>
<td>ASD (39), ASD+ADHD (21), NT (39)</td>
<td>12.16 (10–15)</td>
<td>Inhibition, Flexibility / Shifting, Working Memory, Attention</td>
<td></td>
</tr>
<tr>
<td>Lundervold et al., 2012</td>
<td>Norway</td>
<td>192 (NR)</td>
<td>ASD (9), ADHD (38), ASD+ADHD (11), NT (134)</td>
<td>9.85 (NR)</td>
<td>Attention</td>
<td></td>
</tr>
</tbody>
</table>

¹ This study investigated the EF of ASD+ADHD, ASD, and NT children using the Keio version of the modified Wisconsin card sorting test (KWCST).
² Identical to Kado et al., 2020

The authors compared the conventional CCPT parameters as well as the ex Gaussian parameters of response time across the four groups. They also conducted regression analyses to assess the relationships between response time indices and symptoms of ADHD and ASD in the ASD group (i.e., the ASD+ADHD and ASD-only groups).

The aim of the study was to characterize aspects of EF and attention (as assessed by the CCPT-II) in children with ASD+ADHD.
<table>
<thead>
<tr>
<th>Study</th>
<th>Location</th>
<th>Sample Size</th>
<th>Demographics</th>
<th>Performance Measure(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>McClain et al., 2017</td>
<td>United States of America</td>
<td>113 (94)</td>
<td>ASD (16), ADHD 20, ASD+ADHD (16), ASD+ID (25), ADHD+ID (16)</td>
<td>Attention 7.60 (6–12)</td>
</tr>
<tr>
<td>Ng et al., 2019</td>
<td>United States of America</td>
<td>53 (41)</td>
<td>ASD (15), ADHD (14), ASD+ADHD (24)</td>
<td>Working Memory, Attention 11.32 (7–16)</td>
</tr>
<tr>
<td>Panerai et al., 2014</td>
<td>Italy</td>
<td>61 (49)</td>
<td>ASD (11), ID (13), ASD+ID (8), ASD+ BIF (8), NT+BIF (12), NT (9)</td>
<td>Inhibition, Planning, Flexibility/Shifting, Meta-Cognition, Behavioral Regulation, Global Executive Functioning 10.66 (NR)</td>
</tr>
<tr>
<td>Pitzianti et al., 2016</td>
<td>Italy</td>
<td>51 (47)</td>
<td>ASD (13), ADHD (13), ASD+ADHD (12), NT (13)</td>
<td>Inhibition, Planning, Working Memory 10.74 (8–15)</td>
</tr>
</tbody>
</table>

This study aimed to determine the differences in the severity of inattention and hyperactivity/impulsivity in children diagnosed with ADHD, ASD, ID, ADHD+ID, ASD+ADHD, and ASD+ID. This study aimed to examine the neuropsychological correlates of child patients diagnosed with ADHD, ASD, or ASD + ADHD through a multidisciplinary ASD evaluation clinic.

The aim of the study was to detect which EF components were common to the ASD continuum (from high-to low-functioning ASD) and identify a possible EF profile for ASD individuals.

The goal of this study was to evaluate possible differences among these clinical groups on measures of planning, verbal working memory, response inhibition, and neurological soft signs and the effects of
<table>
<thead>
<tr>
<th>Study</th>
<th>Location</th>
<th>Sample Size</th>
<th>Condition</th>
<th>Metric</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reed et al., 2011</td>
<td>Not Specified</td>
<td>30 (26)</td>
<td>ASD+ID (15), NT (15)</td>
<td>7.13 (4–10)</td>
<td>Flexibility/Shifting</td>
</tr>
<tr>
<td>Saito et al., 2019</td>
<td>Japan</td>
<td>39 (28)</td>
<td>ADHD (11), ASD+ADHD (10), NT (18)</td>
<td>9.30 (NR)</td>
<td>Attention</td>
</tr>
<tr>
<td>Scheirs &amp; Timmers, 2009</td>
<td>Netherlands</td>
<td>115 (91)</td>
<td>ASD (55), ADHD (40), ASD+ADHD (20)</td>
<td>9.70 (6–16)</td>
<td>Working Memory</td>
</tr>
<tr>
<td>Shahabuddin, 2013</td>
<td>United States of America</td>
<td>64 (45)</td>
<td>ASD (16), ADHD (16), ASD+ADHD (16), NT (16)</td>
<td>9.41 (NR)</td>
<td>Attention</td>
</tr>
</tbody>
</table>

The current study aimed to extend the current literature by investigating behavioral flexibility in a sample of low-functioning young children with ASD by using a card sort task, and aimed to relate this performance to psychometrically measured aspects of ASD symptomatology. The study evaluated the power of slow sleep spindles during sleep stage 2 to clarify their relationship with EF, especially with attention, in children with ADHD. The aim of this study was to investigate the intelligence profiles of children with PDD-NOS and ADHD, and to see whether the results of another study could be replicated. The current study aimed to identify sustained and selective attention in children with ASD+ADHD to improve early identification and accurate diagnosis.
<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>N (Gender)</th>
<th>Diagnosis</th>
<th>Mean (Range)</th>
<th>Metacognition, Behavior Regulation, Inhibition, Flexibility/Shifting, Emotional Control</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trezise et al., 2014</td>
<td>Australia</td>
<td>38 (38)</td>
<td>ID (12), ASD+ID (11), Down Syndrome (15)</td>
<td>14.38 (11–19)</td>
<td>Working Memory</td>
<td>The aim of this study was to examine and compare working memory in adolescents with DS, ASD+ID, ID, and NSID using a newly developed working memory task that has both visual and auditory versions.</td>
</tr>
<tr>
<td>Tsermetseli et al., 2018</td>
<td>United Kingdom</td>
<td>40 (28)</td>
<td>ASD+ID (40)</td>
<td>9.20 (6–16)</td>
<td>Metacognition, Behavior Regulation, Inhibition, Flexibility/Shifting, Emotional Control</td>
<td>This study examined everyday EF in the classroom among children and adolescents diagnosed with ASD+ID and their correlations with social impairment and adaptive functioning.</td>
</tr>
</tbody>
</table>

*Note.* This table displays characteristics relative to each study included in the systematic review. Of note, studies did not consistently report all demographic variables (e.g., gender, age). Additionally, the study design of each study was cross-sectional.

**Abbreviations:** Attention-Deficit/Hyperactivity Disorder (ADHD); Autism Spectrum Disorder (ASD); ASD+ADHD (comorbid diagnoses); ASD+ID (comorbid diagnoses); Borderline Intellectual Functioning (BIF); Intellectual Disability (ID); IntD (Internalizing Disorder); Neurotypical (NT); Not Reported (NR); Nonspecific Intellectual Disability (NSID); OPD (Other Psychiatric Disorder); Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS).

1 Due to inconsistencies in reporting of age range, the age ranges were rounded to the nearest year.

2 Bebko & Ricciuti, 2000 - 1 and Bebko & Ricciuti, 2000 - 2 are from the same publication but were separated by “Experiment 1” and “Experiment 2”.

3 Kado et al., 2020 - 1 and Kado et al., 2020 - 2 are from the same publication but were separated by age groups: 1) 5 to 9 years and 2) 10 to 15 years.
Table 1.2

*Assessment Tools (with subtests) Used*

<table>
<thead>
<tr>
<th>Study</th>
<th>Inhibition</th>
<th>Planning and Organizing</th>
<th>Flexibility / Shifting</th>
<th>Working Memory</th>
<th>Attention</th>
<th>Metacognition</th>
<th>Emotional Control</th>
<th>Behavior Regulation</th>
<th>Global EF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bebko &amp; Ricciuti, 2000a</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>UNSRT&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>Bebko &amp; Ricciuti, 2000b</td>
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**Note.** Abbreviations: ADHD-Rating System, Home Version; Attention Deficit Disorders Evaluation Scale, Third Edition (ADDES-3); Behavior Assessment System for Children, 2nd Edition (BASC-2); Behavior Rating Inventory of Executive Function (BRIEF): Parent Version (P), Teacher Version (T); Child Behavior Checklist (CBCL); Parent Version (P); Children’s Color Trail Test (CCTT); Conners Continuous Performance Test (CCPT): Omission (O), Commission (C), Reaction Time (RT); Conners Continuous Performance Test – 2nd edition (CCPT-2): Overall, Omission (O), Commission (C), Reaction Time (RT); Conners Parent Rating Scales, Revised (CPRS-R); Conners Parent Rating Scales, 3rd Edition (CPRS-3); Conners Teacher Rating Scales, 3rd Edition (CTRS-3); Clock Drawing Test (CDT); A Developmental Neuropsychological Assessment, 2nd Edition (NEPSY-II): Auditory Attention (AA), Inhibition (Inh); Delis-Kaplan Executive Function System (D-KEFS): Free Sorting (FS), Sorting Recognition (SR); DKEFS+NEPSY-II-Sort – A composite score combining DKEFS- Sorting Planning and NEPSY-II- Animal Sorting; D2 test of concentration (D2); Five point test (5-point); Executive Composite Score (ECS): combination of HKLLT, D2, 5-point, CCTT, ToL, and GNG; Go/No-Go Task (GNG): Omission (O), Commission (C), Reaction Time (RT); The Hong Kong List Learning Test (HKLLT): Encoding (E), Retention (R), Retrieval – Discrimination Score (RTDS), Retrieval – Correct Hit (RTHC), Retrieval – False Alarm (RTFA), Discrimination Percentage (DP), Retention (RE), Total Learning (TL); Keio version of Wisconsin Card Sorting Test (KWCST): First Step (F), Second Step (S), Categories Achieved (CA), Perseverative errors of Nelson (PEN), Difficulties of maintaining set (DMS), Number of response cards until the first category achieved (NUCA), Non-perseverative errors of Nelson (NPEN); Rey Complex Figure Test (RCFT); Stroop Test (ST): Time (T), Errors (E); Swanson, Nolan, and Pelham, version IV (SNAP-IV): Parent Version (P); Test Battery for Attention Performance – Go/No Go Task (TAP-GNG); The Tower of California
Test (ToC); Tower of London (ToL): Total Score (TS), Total Time (TT); Trail Making Test (TMT): Trail A (A), Trail B (B); Unspecified Continuous Performance Test (UNCPT): Omission (O), Commission (C), Reaction Time (RT); Unspecified Card Sorting Task (UNCST): Phase 1 (1), Phase 2 (2), Total (T), Initial (I); Unspecified Recall Readiness (UNRR); Unspecified Serial Recall Task (UNSR); Unspecified Working Memory Task (UNWMT): Visual Memory Correct (VMC), Visual Memory Maximum (VMM), Auditory Memory Correct (AMC), Auditory Memory Maximum (AMM); Wechsler Intelligence Scale for Children, Third Edition – Digit Span (WISC-III-DS); Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV): Digit Span (DS), Letter Number Sequencing (LNS), Working Memory Index (WMI); Wechsler Intelligence Scale for Children, Fifth Edition – Working Memory Index (WISC-V-WMI); Wisconsin Card Sorting Test (WCST): Flexibility Errors Percentage (FE), Perseverative Response Percentage (R), Perseverative Errors Percentage (PE), Number of Categories (N)

aPerformance-based measure

bIndirect measure
### Table 1.3

*Significant Differences and Similarities with EF*

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<th>Study</th>
<th>Inhibition</th>
<th>Planning / Organizing</th>
<th>Flexibility / Shifting</th>
<th>Working Memory</th>
<th>Attention</th>
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<td>--</td>
<td>--</td>
<td>1\textsuperscript{NSD}; 2\textsuperscript{ASD+ADHD} &gt; ASD &gt; NT</td>
</tr>
<tr>
<td>Kado et al., 2020b</td>
<td>1\textsuperscript{NSD}</td>
<td>--</td>
<td>1\textsuperscript{ASD} &gt; ASD + ADHD; 2\textsuperscript{NSD}</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1\textsuperscript{ASD} &gt; ASD + ADHD; 2\textsuperscript{NSD}</td>
</tr>
<tr>
<td>Lundervold et al., 2012</td>
<td>--</td>
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<td>--</td>
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<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1\textsuperscript{NSD}; 2\textsuperscript{ADHD} &gt; NT; 3\textsuperscript{NSD}; 4\textsuperscript{ADHD} &gt; NT</td>
</tr>
<tr>
<td>McClain et al., 2017</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1\textsuperscript{ADHD} &gt; ASD + ID; 2\textsuperscript{NSC}</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Ng et al., 2019</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1\textsuperscript{NSD}</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1, 2, 3, 4\textsuperscript{NSD}</td>
</tr>
</tbody>
</table>

\textsuperscript{1}ASD+ID: Autism Spectrum Disorder + Intellectual Disability
\textsuperscript{2}NSD: Normal Intellectual Development
\textsuperscript{3}ADHD: Attention Deficit Hyperactivity Disorder
\textsuperscript{4}NT: Normal
<table>
<thead>
<tr>
<th>Study</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panerai et al., 2014</td>
<td>1NSD; 1ASD+ID &gt; ID; 1ASD+BIF &gt; BIF</td>
</tr>
<tr>
<td></td>
<td>1ASD &gt; NT; 1ASD+BIF &gt; NT+BIF; 1ASD+ID &gt; ID</td>
</tr>
<tr>
<td>Pitzianti et al., 2016</td>
<td>1, 3ASD+ADHD = ADHD &gt; NT; 2ASD = ADHD = ASD+ADHD &gt; NT</td>
</tr>
<tr>
<td></td>
<td>1ASD+ADHD &gt; ASD &gt; NT; 1ASD+ADHD = ADHD &gt; NT; 2ASD+ADHD = ASD+ADHD &gt; NT</td>
</tr>
<tr>
<td></td>
<td>1ADHD &gt; ASD &gt; NT; 1ADHD &gt; ASD+ADHD = ASD</td>
</tr>
<tr>
<td>Reed et al., 2011</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>1NSD; 2, 3ASD+ID &gt; NT</td>
</tr>
<tr>
<td>Saito et al., 2019</td>
<td>1ASD+ADHD = ADHD &gt; NT</td>
</tr>
<tr>
<td></td>
<td>--</td>
</tr>
<tr>
<td>Scheirs &amp; Timmers, 2009</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>1NSC</td>
</tr>
<tr>
<td>Shahabuddin, 2015</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>1, 2ASD+ADHD &gt; ASD &gt; ADHD &gt; NT</td>
</tr>
<tr>
<td></td>
<td>2ASD+ADHD &gt; ASD &gt; ADHD &gt; NT</td>
</tr>
<tr>
<td></td>
<td>4ASD+ADHD &gt; ADHD &gt; NT</td>
</tr>
<tr>
<td></td>
<td>5ASD &gt; ASD &gt; ADHD &gt; NT</td>
</tr>
<tr>
<td>Study</td>
<td>Measure 1</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Trezise et al., 2014</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Tsermentseli et al., 2018</td>
<td>1(\text{NSC} )</td>
</tr>
</tbody>
</table>

**Note.** Abbreviations: Autism Spectrum Disorder (ASD); Attention-Deficit/Hyperactivity Disorder (ADHD); ASD+ADHD (comorbid diagnoses); Intellectual Disability (ID); ASD+ID (comorbid diagnoses); OPD (Other Psychiatric Disorder); IntD (Internalizing Disorder); DS (Down Syndrome); BIF (Borderline Intellectual Functioning); NSC (No Statistical Comparisons); NSD (No Significant Differences); Neurotypical (NT)

1-5 Number corresponds to the order of measures listed on Table 2.
Table 1.4  

Mean Z-scores for Individual Areas of EF for Studies Reporting Standardized Scores, M(SD)

<table>
<thead>
<tr>
<th>Area of EF</th>
<th>ASD</th>
<th>ADHD</th>
<th>ID</th>
<th>ASD+ADHD</th>
<th>ASD+ID</th>
<th>NT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working Memory</td>
<td>0.69(0.80)</td>
<td>0.60(1.01)</td>
<td>--</td>
<td>1.07(0.69)</td>
<td>--</td>
<td>0.60(1.95)</td>
</tr>
<tr>
<td>Number of Studies (k)</td>
<td>9</td>
<td>8</td>
<td>--</td>
<td>9</td>
<td>--</td>
<td>2</td>
</tr>
<tr>
<td>Number of Participants (n)</td>
<td>187</td>
<td>268</td>
<td>--</td>
<td>199</td>
<td>--</td>
<td>141</td>
</tr>
<tr>
<td>Inhibition</td>
<td>0.30(0.64)</td>
<td>0.25(0.35)</td>
<td>--</td>
<td>1.08(0.32)</td>
<td>2.23(--)</td>
<td>--</td>
</tr>
<tr>
<td>Number of Studies (k)</td>
<td>3</td>
<td>3</td>
<td>--</td>
<td>3</td>
<td>1</td>
<td>--</td>
</tr>
<tr>
<td>Number of Participants (n)</td>
<td>39</td>
<td>81</td>
<td>--</td>
<td>39</td>
<td>40</td>
<td>--</td>
</tr>
<tr>
<td>Behavior Regulation</td>
<td>0.80(--)</td>
<td>--</td>
<td>-0.99(--)</td>
<td>--</td>
<td>2.01(1.34)</td>
<td>-1.52(--)</td>
</tr>
<tr>
<td>Number of Studies (k)</td>
<td>1</td>
<td>--</td>
<td>--</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Number of Participants (n)</td>
<td>11</td>
<td>--</td>
<td>13</td>
<td>48</td>
<td>9</td>
<td>--</td>
</tr>
<tr>
<td>Planning/Organizing</td>
<td>0.98(0.28)</td>
<td>0.69(0.41)</td>
<td>--</td>
<td>1.23(0.46)</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Number of Studies (k)</td>
<td>4</td>
<td>4</td>
<td>--</td>
<td>4</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Number of Participants (n)</td>
<td>52</td>
<td>108</td>
<td>--</td>
<td>52</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Attention</td>
<td>1.22(0.53)</td>
<td>1.86(0.78)</td>
<td>1.57(0.53)</td>
<td>1.88(0.81)</td>
<td>1.34(0.49)</td>
<td>0.26(0.74)</td>
</tr>
<tr>
<td>Number of Studies (k)</td>
<td>15</td>
<td>14</td>
<td>2</td>
<td>15</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Number of Participants (n)</td>
<td>395</td>
<td>767</td>
<td>40</td>
<td>445</td>
<td>50</td>
<td>384</td>
</tr>
<tr>
<td>Emotional Control</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>2.74(--)</td>
<td>--</td>
</tr>
<tr>
<td>Number of Studies (k)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1</td>
<td>--</td>
</tr>
<tr>
<td>Number of Participants (n)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>40</td>
<td>--</td>
</tr>
<tr>
<td>---------------------------</td>
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<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Metacognition</td>
<td>3.25(--)</td>
<td>--</td>
<td>4.05(--)</td>
<td>--</td>
<td>3.20(0.67)</td>
<td>0.92(--)</td>
</tr>
<tr>
<td><strong>Number of Studies (k)</strong></td>
<td>1</td>
<td>--</td>
<td>1</td>
<td>--</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td><strong>Number of Participants (n)</strong></td>
<td>11</td>
<td>--</td>
<td>13</td>
<td>--</td>
<td>48</td>
<td>9</td>
</tr>
<tr>
<td>Flexibility/Shifting</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>3.27(--)</td>
<td>--</td>
</tr>
<tr>
<td><strong>Number of Studies (k)</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1</td>
<td>--</td>
</tr>
<tr>
<td><strong>Number of Participants (n)</strong></td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>40</td>
<td>--</td>
</tr>
</tbody>
</table>

*Note.* This table displays the mean Z-scores and associated standard deviations for each area of EF as grouped by diagnostic group, in addition to the number of studies (k) and number of participants (n) contributing to the Z-score. The scores are based on the studies (k = 12) that reported standardized scores.

**Abbreviations:** Attention-Deficit/Hyperactivity Disorder (ADHD); Autism Spectrum Disorder (ASD); co-occurring ASD and ADHD (ASD+ADHD); co-occurring ASD and ID (ASD+ID); Intellectual Disability (ID); Neurotypical (NT).
Figure 1.1.

Flow Diagram of the Article Identification Process

Records identified through database searching
\((k = 3,752)\)

Records after duplicates removed
\((k = 1,710)\)

Records screened
\((k = 1,710)\)

Records excluded
\((k = 1,641)\)

Full-text articles assessed for eligibility
\((k = 69)\)

Full-text articles excluded, with reasons
\((k = 49)\)

Articles included in ancestral review
\((k = 20)\)

Articles identified through ancestral review
\((k = 4)\)

Articles included in this systematic review
\((k = 24)\)
Figure 1.2.

Mean Z-scores of Standardized Assessments Based on Area of EF and Diagnostic Group

Note. This figure represents the means of the standardized scores (i.e., T-scores, Standard Scores, Scaled Scores) reported in the studies for each area of EF and grouped by diagnostic group. Standard Scores and Scaled Scores were reverse scored so that higher Z-scores signify more impairments.

Abbreviations: Attention-Deficit/Hyperactivity Disorder (ADHD); Autism Spectrum Disorder (ASD); co-occurring ASD and ADHD (ASD+ADHD); co-occurring ASD and ID (ASD+ID); Intellectual Disability (ID); Neurotypical (NT).
CHAPTER III

THE IMPACT OF CO-OCCURRING ADHD AND ID SYMPTOMATOLOGY ON THE EXECUTIVE FUNCTIONING OF AUTISTIC CHILDREN

Abstract

Autism is a neurodevelopmental disorder with complex and varying symptomology. Symptomology including social communication deficits and restricted/repetitive behaviors often overlap with other NDDs including ADHD and ID, making it difficult to differentially diagnose. Additionally, NDDs also share challenges with executive functioning which can impact several areas of functioning including social and academics. This study sought to explore the how co-occurring ADHD and ID impact the executive functioning of autistic children by using an indirect measure and model of executive functioning. Results support increased hyperactivity/impulsivity and social communication deficits are associated with executive dysfunction among children with autism whereas inattention, restricted/repetitive behaviors, and child demographics (i.e., child age and gender) were not. Additionally, emotion regulation was found to be a relative weakness when compared to cognitive and behavior regulation in this sample of autistic children. The findings have clinical implication for differential diagnosis strategies and targeted interventions. Future research may benefit from reproducing the study with specified age groups as well as early childhood populations. Additionally, exploring how executive functioning evolves and progresses from early childhood through adolescence with autistic children would inform differential diagnosis and targeted interventions for specified age groups.
Introduction

Autism\textsuperscript{6} is a neurodevelopmental disorder (NDD) characterized by social communication and interaction deficits as well as restricted and repetitive patterns of behaviors, interests, and activities (American Psychiatric Association [APA], 2022. Autism currently impacts almost 3\% (estimated 1 in 36) of children in the United States (Maenner et al., 2023). Between 2006 and 2020, the prevalence of autism increased three-fold from 1 in 110 children to 1 in 36 children (Maenner et al., 2023). In addition, the Autism (AU) eligibility category comprises about 12\% of all children served in special education (SPED) in the United States public schools (U.S. Department of Education, Office of Special Education and Rehabilitation Services, 2021). Like medical diagnoses, the representation of children receiving SPED services under the AU eligibility category has more than doubled in the last decade, from approximately 5\% in 2008 to 12\% in 2020 (U.S. Department of Education, Office of Special Education and Rehabilitation Services, 2022).

Assessing for Autism

Early and appropriate identification of autism is crucial for accessing appropriate services and making optimal gains (e.g., Debodinance et al., 2017; Hampton & Kaiser, 2016; Peters-Schefféret al., 2011; Reichow, 2012). Evaluating a child for autism is complex and requires multiple assessment tools that reflect various areas of functioning (e.g., cognitive, language, social). For an evaluation limited to assessing for autism, it is

\textsuperscript{6} The terms “ASD” and “autism” will be used interchangeably throughout the manuscript to represent the identity preferences of those with the disorder.
recommended that a cognitive assessment, autism screening tool (e.g., Autism Spectrum Rating Scales [ASRS; Goldstein & Naglieri, 2009], Social Communication Questionnaire [SCQ; Rutter et al., 2003]), clinical interview, emotional and adaptive questionnaires, and autism-behavior observation measures (e.g., Autism Diagnostic Observation Schedule, Second Edition [ADOS-2; Lord et al., 2012], Childhood Autism Rating Scale, Second Edition [CARS-2]; Schopler et al., 2010) is administered (Kroncke et al., 2016). Best practice suggests a comprehensive evaluation that assesses for the presence of autism, as well as other possible developmental, emotional, behavioral, sensory, and social concerns, is preferred (Di Renzo et al., 2019; Kronke et al., 2016; Manning-Courtney et al., 2013) in the context of an interdisciplinary team (Campbell et al., 2020). An interdisciplinary approach to autism identification offers a whole picture of the child that includes their strengths and limitations. To conduct a comprehensive interdisciplinary evaluation, a team of professionals (e.g., psychologist, speech and language pathologist, occupational therapist) work together to administer various discipline-specific assessments which then inform clinical opinion and impressions. The team collaborates and concludes whether autism is present, as well as identifies co-occurring differences (e.g., cognitive, emotional, behavioral, language, sensory). Although a brief evaluation is possible and is often more financially feasible for families, it makes it difficult for clinicians to determine a differential or co-occurring difficulty that may better explain the child’s presentation (Campbell et al., 2020; Kroncke et al., 2016). Special consideration should be given to attention-deficit/hyperactivity disorder (ADHD) and intellectual disability (ID) due to their statuses as the most common co-occurring NDDs with ASD (Hyman et al., 2020). Furthermore, when this determination cannot be made, children and
their families may not receive the most appropriate and targeted recommendations or services.

**Assessing for Co-Occurring ID and ADHD**

Cognitive and adaptive assessments are typically part of test batteries when assessing for many NDDs. Of children diagnosed with autism, approximately 38% have a co-occurring ID (Maenner et al., 2023). Therefore, it is essential that it be determined whether ID is present in autistic children. To assess for ID, children are administered a cognitive assessment and caregivers complete either an adaptive skills interview or questionnaire. Children with ID typically have considerable challenges with language, reasoning, knowledge, interpersonal skills, and adaptive skills, in addition to behaviors associated with social skills difficulties, restricted behaviors, and repetitive speech (Thurm et al., 2019; Trammel et al., 2013). Autism and ID often share common characteristics (e.g., language delays, adaptive skill deficits, social skills impairments). When compared to children with ID without autism, autistic children demonstrate more impairment with nonverbal communication skills and social reciprocity in addition to increased restricted interests, rigidity adhering to routines, stereotyped/repetitive behaviors, and preoccupation with parts of objects (Pedersen et al., 2016). Children with ID may communicate socially through nonverbal gestures as well as demonstrate social abilities related to play and social reciprocity, and behavioral flexibility (Kroncke et al., 2016; Pedersen et al., 2016).

For a diagnosis of autism, the DSM-5-TR (APA, 2022) requires that social communication skills are more impaired than what would be expected for the individual’s developmental age. This guideline can be used to differentiate autism from ID as well as
determine whether a co-occurring diagnosis of ID is appropriate. In order to determine if ID is present, a child’s cognitive and adaptive skills must be significantly delayed compared to their same-aged peers (e.g., approximately two standard deviations below the mean; APA, 2022). Autistic children with ID have been shown to have more adaptive skills deficits than children with autism or ID (Trammell et al., 2013). In summary, nonverbal communication (e.g., eye contact, gestures), social reciprocity (e.g., referencing others, seeking social attention, sharing enjoyment), and restricted/repetitive behaviors (e.g., special interests, rigid routines, preoccupation with parts of objects) are fundamental behaviors that can be used to differentiate autism from ID (Kroncke et al., 2016; Pedersen et al., 2016). Autistic children with ID have the characteristics of autism (i.e., restricted repetitive patterns of behaviors/interests, social communication/interaction deficits), as well as significantly delayed cognitive abilities and adaptive skills (APA, 2022).

Behavior rating scales (i.e., broad-band and narrow-band) from multiple respondents (e.g., parent, teacher, child), continuous performance tests, and behavior observations are common techniques to assess for ADHD. Hallmark signs of ADHD include difficulties with focus and concentration, poor attention to detail, difficulties listening and following through with tasks, being easily distracted, difficulties with planning and organizing, as well as significant hyperactivity and impulsivity (APA, 2022; Barkley, 2022; Tye et al., 2013). Although social skill difficulties are characteristic of autistic children (APA, 2022), problems with social relationships are also common with ADHD (Antshet & Russo, 2019; Mikami & Normand, 2015). Behaviors associated with ADHD (e.g., difficulties waiting, blurting out responses in class) often result in social and
relationship difficulties with peers and others (Antshet & Russo, 2019). To differentiate autism from ADHD, with respect to social skill difficulties, clinicians should question the underlying reasoning. Specifically, it appears that social difficulties with autism are due to the absence of prosocial behaviors (e.g., eye contact, social-emotional reciprocity), whereas with ADHD the difficulties are associated with the presence of antisocial behaviors (e.g., excessive hyperactivity/impulsivity, appearing to not listen; Antshet & Russo, 2019). Although estimates are variable, ADHD co-occurs in 40 to 70% of childhood cases of autism (Joshi et al., 2014; Joshi et al., 2017; Kaat et al., 2013; Salazar et al., 2015). Kroncke et al. (2016) suggest that attention and impulsivity/hyperactivity should be assessed when considering autism. Specifically, impulsivity and social reciprocity should be assessed. Children with ADHD are expected to have the ability to participate in pretend and creative play activities (Kroncke et al., 2016). Autism may impact a child’s ability to attend to activities; however, these attention difficulties are not typically pervasive as with ADHD (Deprey and Ozonoff, 2009; Mikami et al., 2019). With appropriate reinforcement, autistic children can attend to activities without significant difficulty. Individuals who display significant difficulties with impulsivity, as well as deficits in social reciprocity, likely have both autism and ADHD.

Although ADHD and ID are common co-occurring NDDs with autism, not all children receive comprehensive evaluations that evaluate for differential and co-occurring disorders (Kroncke et al., 2016). Furthermore, many autistic children exhibit significant inattention, hyperactivity/impulsivity, and intellectual deficits due to overlapping symptomology (e.g., Antshet & Russo, 2019; Craig et al., 2015; Thurm et al., 2019). It is possible that although a co-occurring diagnosis of ADHD or ID may be
appropriate, children may not receive a co-occurring diagnosis due to receiving an autism diagnosis at a young age when their inattentive/hyperactive behavior or intellectual functioning was not a primary concern. In summary, it is common for autistic children to display varying levels of inattention, hyperactivity/impulsivity, and intellectual functioning as well as may go undiagnosed with co-occurring ADHD or ID.

**Executive Functions**

A possible approach to facilitating better identification of autism and other NDDs, namely ID and ADHD, may be to evaluate executive functions (EFs). EFs are complex higher-order cognitive processes that are involved in the ability to adapt and respond to new situations (Lezak, 2012). EF is often used as a comprehensive term to include a list of specific skills that require an individual to flexibly respond to novel information, environments, or situations (Elliot, 2003). Specific EF skills often include but are not limited to, inhibition, cognitive flexibility, planning and organizing, attention, and self-regulation. EF can play a considerable role in an individual’s cognitive, emotional, and social skill functioning (Lezak et al., 2012). In addition, EF deficits may have a significant impact on academic performance (Best et al., 2011).

**Measuring Executive Functioning**

Areas of EF (e.g., working memory, inhibition, cognitive flexibility) are highly correlated making it difficult to definitively examine EF presentations across conditions. Several models of EF (e.g., Elliot, 2003, Gioia et al., 2015, Lezak, 2012, Miyake et al., 2000) have been conceptualized to better understand and define EF when considering the overlap and correlations between areas of EF. Gioia and colleagues (2015) developed a rating form to assess the EF of children (i.e., Brief Rating Inventory of Executive
Function, Second Edition [BRIEF-2]) that evaluates various areas including working memory, inhibition, switching, and emotion control, among others. The authors explain the overlap between various areas of EF by using a model of regulation. The model follows the following structure: Behavior regulation (includes inhibition and self-monitoring), emotion regulation (includes shifting and emotional control), and cognitive regulation (includes initiation, working memory, planning/organizing, task-monitoring, and organization of materials) (Gioia et al., 2013; see Figure 1 for visualization). Overall, it may be more meaningful to use a model of EF when determining an individual’s EF strengths and weaknesses, rather than assessing specific areas of EF that may not be distinct from one another.

Another consideration when assessing EF is whether to use performance-based (i.e., clinician-administered) or indirect (i.e., behavior rating forms) assessments to evaluate an individual’s level of EF. A systematic review (Benallie et al., 2021) of executive functioning skills in children with autism and related NDDs suggests that performance-based and indirect assessments produce incongruent findings. Furthermore, the systematic review supports previous findings that indicate performance-based and indirect assessments are both valid measures of EF but that they are measuring different constructs (Toplak et al., 2013). Specifically, performance-based assessments measure the cognitive aspect of EF whereas indirect assessments measure the behavioral aspect. Research indicates that performance-based and indirect assessments are moderately correlated when assessing larger domains (e.g., BRIEF-2 Cognitive Regulation Index) but not at a subscale level (e.g., inhibition) (Miranda et al., 2015). While both performance-based and indirect assessments of EF provide meaningful information about
an individual’s functioning, indirect assessments may be more ecologically valid.

Furthermore, larger domains of EF—such as those offered by the BRIEF-2 (i.e., Emotion Regulation Index [ERI], Behavior Regulation Index [BRI], Cognitive Regulation Index [CRI])—may be better to use than smaller subscales when assessing EF not only because of the overlap between areas of EF but also because they are more strongly correlated with performance-based measures of EF (Miranda et al., 2015).

**Impact of ADHD Symptomology and Intelligence on Executive Functioning**

**ADHD Symptomology.** Children with ADHD, autism, and/or ID often demonstrate significant executive dysfunctioning (e.g., APA, 2022; Benallie et al., 2021; Channon et al., 2003; Corbett et al., 2009; Craig et al., 2016; Henry et al., 2010; Liss et al., 2011; Otterman et al., 2019). However, because of the complexity and variability of EF, many children with NDDs likely demonstrate overlapping and differing EF presentations. Childhood autism is associated with deficits in vigilance (Corbett et al., 2009), inhibition (Corbett et al., 2009; Demetriou et al., 2018; Hill, 2004), cognitive flexibility/switching (Corbett et al., 2009; Demetriou et al., 2018; Hill, 2004; Lai et al., 2017), planning (Demetriou et al., 2018; Hill, 2004; Lai et al., 2017), and working memory (Corbett et al., 2009; Demetriou et al., 2018; Lai et al., 2017). Compared to neurotypical (NT) peers, children with autism and ADHD both display EF difficulties in inhibition, planning, and verbal working memory (Pitzianti et al., 2016). However, when compared to each other, autistic children exhibit significant impairments in planning and flexibility, whereas children with ADHD show more deficits with inhibition and working memory (Sinzig et al., 2008b). In terms of attention, children with ADHD appear to have more difficulties with sustained (Sinzig et al., 2008a) and orienting attention (Tye et al.,
2014), while children with autism have increased difficulties with divided attention (Sinzig et al., 2008a). Furthermore, a systematic review examining EF in autistic children with co-occurring ADHD found that many individuals with co-occurring autism and ADHD have significantly more challenges with working memory, inhibition, and planning as compared to autistic children without ADHD (Benallie et al., 2021). In comparison to NT controls, autism, ADHD, and autism+ADHD diagnostic groups have elevated inattention, whereas children with ADHD and autism+ADHD have more inattention than autistic children (Craig et al., 2015). Dajani and colleagues (2016) showed that autistic children with co-occurring ADHD have more impaired EF skills than those with autism and ADHD; however, specific EF deficits (e.g., inhibition, initiation, planning) were not reported.

Considering autistic children are often inappropriately undiagnosed with ADHD, it is important to consider research that examines ADHD symptom severity and cognitive functioning concerning EF. Research suggests that children with elevated ADHD symptoms in addition to an autism diagnosis demonstrate more EF difficulties than children with autism without significant ADHD symptoms (e.g., Cremone-Caira et al., 2019; Lukito et al., 2017; Neely et al., 2016). Autistic children with high levels of inattention demonstrate poorer verbal working memory as compared to ADHD controls (Andersen et al., 2013; Neely et al., 2016). When autism symptoms were controlled for, De Vries and Geurts (2014) found that ADHD characteristics did not impact working memory or inhibition. Similarly, Neely and colleagues (2016) found that there were no differences in inhibition or working memory between autistic children with high levels of ADHD symptoms when compared to children with ADHD. Findings from Sinzig and
colleagues (2008b) support the absence of working memory differences between these groups. However, their findings suggested that elevated ADHD symptoms in autistic children are associated with more inhibition difficulties. In contrast, Cooper and colleagues (2014) found that children with ADHD with increased autism symptomology displayed significant working memory deficits. These working memory deficits persisted when ADHD severity was accounted for. Cognitive flexibility as well as planning and organizing skills do not differ between autistic children and those with elevated levels of ADHD symptoms (Sinzig et al., 2008b). In summary, autistic children with high rates of ADHD symptoms demonstrate more executive dysfunction than their autistic counterparts. However, research is inconclusive regarding which areas of EF differ between autistic individuals with and without co-occurring ADHD.

**Intelligence.** Differences in EF skills are apparent between children with autism, ID, and autism and cooccurring (Panerai et al., 2014; Trezise et al., 2014). However, limited research has been conducted looking at EF in autistic children with co-occurring ID. Children with co-occurring autism and ID have been shown to have more severe working memory impairments than those with ID (Trezise et al., 2014). A study conducted by McClain et al. (2017) showed significantly higher elevations of inattention in children with ADHD and autism+ADHD compared to children with ID and autism+ID. A study conducted by Panerai and colleagues (2014) revealed that autistic children without co-occurring ID have more impairments with overall EF, inhibition, emotional control, working memory, planning, and monitoring compared to autistic children with co-occurring ID. Notably, the results of this study show that children with autism+ID do not have unique EF deficits; however, both children with autism and
autism+ID have impairments in shifting. In early childhood children, McClain et al (2022) found that children with ID exhibited the most EF difficulties, but working memory was the most impaired EF domain autism and autism+ID diagnostic groups.

Although limited research has investigated EF differences between autism and autism+ID, related research offers insight into the impact of intelligence levels on EF in autistic children and other NDDs. Cooper and colleagues (2014) found that increased autism symptoms in children with ADHD were associated with lower intellectual functioning as compared to children with ADHD. This finding suggests that when significant autism and ADHD symptoms are both present, there is a higher likelihood of poor intellectual functioning. Furthermore, Blijd-Hoogewys and colleagues (2014) found that EF areas of inhibition, cognitive flexibility, working memory, planning/organizing, and self-monitoring were associated with lower performance IQ in autistic children. However, their findings indicate that verbal IQ was not associated with EF deficits in this population. In a general population of adults, research suggests that intelligence is associated with working memory but not with inhibition or shifting (Friedman et al., 2006). Furthermore, in a sample of 17- to 84-year-old adults referred for neuropsychological evaluations, a significant relationship between EF and intelligence was found (Duff et al., 2005). Lastly, research conducted by Antshel and colleagues (2010) showed that high-intelligence adults with ADHD had more EF difficulties when compared to high-intelligence adults without ADHD. Notably, the authors also found that when only the group of adults with ADHD and higher intelligence was being considered, only 8% of the sample demonstrated executive dysfunction. Although this study suggests that ADHD symptoms may be related to more EF deficits, it also implies that higher
intelligence may act as a protective factor against executive dysfunction. In summary, this research may indicate that there is an interaction between the combination of autism and ADHD symptoms and intellectual functioning on EF. It also indicates that higher intelligence may result in fewer EF deficits even in groups that typically demonstrate executive dysfunction (e.g., ADHD).

**Current Study**

EF deficits are common in children with autism and other NDDs, particularly ADHD and ID (e.g., APA, 2022; Benallie et al., 2021; Channon et al., 2003; Corbett et al., 2009; Craig et al., 2016; Henry et al., 2010; Otterman et al., 2019), which are among the most common co-occurring diagnoses with autism (Hyman et al., 2020). Furthermore, specific NDDs may be associated with unique EF impairments (e.g., Corbett et al., 2009; Demetriou et al., 2018; Hill, 2004; Lai et al., 2017; Pitzianti et al., 2016; Trezise et al., 2014). The literature investigating the impact of co-occurring ADHD and ID diagnoses and symptomology on the EF of autistic children is limited and contradictory (Benallie et al., 2021). Although the literature is inconsistent regarding specific areas of EF deficits in autistic children, the literature suggests that children with autism and related NDDs demonstrate EF difficulties and may experience worsened EF difficulties when a co-occurring NDD is present (e.g., Benallie et al., 2021). The inconsistencies in the literature may be due to varying levels of symptom severity, undiagnosed co-occurring ADHD and ID, and overlapping areas of EF. This study seeks to investigate the effect of autism symptomology, ADHD symptomology, and intelligence on EF in autistic children. Furthermore, this study will use the model of EF developed by Gioia and colleagues (2015) for the BRIEF-2 which separates the various areas of EF into three larger
constructs (i.e., emotion regulation, behavior regulation, cognitive regulation). This approach to measuring EF is supported by the high ecological validity of behavior rating scales as well as the strong correlation between the larger EF composites and performance-based assessments (Miranda et al., 2015). By further investigating the impact of symptom severity and intelligence on the EF of autistic children, autism evaluations can be better informed to differentiate disorders and targeted interventions can be developed.

To add to the current literature, this study seeks to answer the following research question: how do autism symptomology, ADHD symptomology, and intelligence impact the EF of autistic children? We anticipate that elevated autism and ADHD symptoms as well as lower intellectual abilities among autistic children will result in worsened EF skills.

Method

Participants

Participants in the current study included 65 autistic children between the ages of 6 and 17 years and their caregivers. Approximately 46% of the sample had a co-occurring ADHD ($n = 30$) and 9% had a co-occurring ID ($n = 6$). Participating children were predominately White ($n = 41, 63.1\%$) males ($n = 47, 72.1\%$) with an average age of 10.7 years ($SD = 3.2$) who were receiving special education (SPED) services ($n = 40, 61.5\%$). Due to differences in the demographic information collected between research studies and the university clinic database, not all child and caregiver demographic information is
available. See Table 1 for complete demographic information, including available caregiver demographic information.

Observed mean scores for measures of intellectual functioning (i.e., Wechsler Preschool and Primary Scale of Intelligence, Fourth Edition [WPPSI-IV], Wechsler Intelligence Scale for Children, Fifth Edition [WISC-V], Wechsler Adult Intelligence Scale, Fourth Edition [WAIS-IV], Wechsler Abbreviated Scale of Intelligence, Second Edition [WASI-II]), autism symptomology (i.e., Autism Spectrum Rating Scales [ASRS]), ADHD symptomology (i.e., Conners 3rd Edition, Parent Form [Conners 3P]), and executive functioning (i.e., Behavior Rating Inventory of Executive Function, Second Edition [BRIEF-2]) are contained in Table 2, organized by the number of children who completed the specified measure, mean, standard score, and range of scores. Overall, children in the current study demonstrated an average full-scale intelligence quotient (FSIQ; i.e., intellectual functioning) of 99.5 ($SD = 18.6$; range = 59 – 135). Based on caregiver report of symptom severity, children exhibited significantly elevated autism symptoms as evidenced by social communication deficits ($M = 66.1; SD = 8.0; range = 48 – 85$) and unusual behaviors ($M = 68.1; SD = 5.8; range = 52 – 79$). ADHD-related behaviors were also reported and clinically elevated as children were rated to have significantly high inattention ($M = 73.3; SD = 13.0; range = 37 – 90$) and hyperactivity/impulsivity ($M = 77.1; SD = 12.0; range = 36 – 90$). Further, children were rated by their caregivers to have significant executive dysfunction specifically concerning behavior regulation ($M = 70.7; SD = 9.6; range = 49 – 86$), emotion regulation ($M = 76.1; SD = 8.6; range = 50 – 94$), and cognitive regulation ($M = 66.5; SD = 8.6; range = 46 – 81$).
Data were collected between 2017 and 2022 through previous research studies as well as new recruitment. A pause in data collection occurred between March 2020 and October 2021 due to in-person research restrictions related to the COVID-19 pandemic. Child participants were required to have a formal diagnosis by an appropriately licensed professional and/or be receiving special SPED services under the AU eligibility category. Notably, all children had a formal diagnosis of ASD. Children were also required to speak English fluently (this was necessary because the standardized measures being used are validated in English and the administrators were not properly trained to interpret/score the chosen measures with other languages) and have adequate verbal abilities (ability to respond and complete required tasks). In addition, caregivers were required to speak English fluently to complete the required behavior rating scales. Children and their caregivers were recruited through 1) secondary data and 2) community outreach efforts (e.g., past research and clinic contact lists, flyers shared on school and clinic listservs and in local businesses, word of mouth from providers). Secondary data were used from two past research studies, which will be referred to as past research study #1 and past research study #2, and a university clinic database.

Measures

**Demographic Questionnaire**

Newly recruited caregivers completed a survey online via REDCap (Research Electronic Data Capture) a secure, web-based software platform designed to support data capture for research studies, providing 1) an intuitive interface for validated data capture; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4)
procedures for data integration and interoperability with external sources (Harris et al., 2009; Harris et al., 2019). The survey (see Appendix C) included demographic and background information regarding both child and caregiver demographics (see Table 1 for complete demographics). One of the past research studies also required the completion of the same demographic questionnaire. Due to the inability to control what demographic information had been collected through past research studies and the university diagnostic clinic, not all demographic information is available for all children and caregivers. See Figure 2 for an explanation of the demographic information collected for each recruitment process.

**Autism Spectrum Rating Scales (ASRS), Caregiver Report**

The ASRS (Goldstein & Naglieri, 2009) is a 71-item rating scale for children ages 2 to 18 years designed to evaluate symptoms and associated behaviors of autism. The rating form is available in two age-specific versions: young children (2 to 5 years) and youth (6 to 18 years). This study used the version for 6- to 18-year-old children. The ASRS reports an overall score (i.e., Total Score) and 3 primary scales (i.e., Social/Communication, Unusual Behaviors, Self-Regulation). Caregivers answered each item by indicating how often (i.e., 0 = “never” to 4 = “very frequently”) their child engaged in the specified behavior. Internal consistency ($\alpha = .74$ to .97) and test-retest—over a 2- to 4-week interval ($r = .72$ to .93)—analyses indicate that the ASRS has acceptable reliability. Additionally, discriminant validity testing suggests that the ASRS adequately predicts group membership of autism with an overall correct classification of 92%. Caregivers completed the rating form to measure levels of autism symptomology.
ASRS T-scores from the Social/Communication and Unusual Behaviors subscales were used to examine autism symptom severity.

**Behavior Rating Inventory of Executive Function, Second Edition (BRIEF-2), Caregiver Form**

The BRIEF-2 (Gioia et al., 2015) is a 63-item rating scale that measures a child’s (aged 5 to 18 years) executive functioning skills. Caregivers completed the BRIEF-2 to assess the child's executive functioning skills. Caregivers reported their child’s behavior based on a Likert scale (i.e., 1 = “never” to 3 = “often”). The BRIEF-2 reports an overall score (i.e., Global Executive Composite), 3 indices (i.e., Emotion Regulation Index [ERI], Behavioral Regulation Index [BRI], Cognitive Regulation Index [CRI]), and 9 clinical scales (i.e., Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Task-Monitor, Organization of Materials, Self-Monitor).

Internal consistency testing ($\alpha = .76$ to $.97$) indicates that the BRIEF-2 has acceptable reliability. Notably, internal consistency for all indices (i.e., ERI, BRI, CRI) ranged from good to excellent ($\alpha = .90$ to $.96$). Test-retest reliability—over an approximate 2.9-week interval ($r = .67$ to $.92$)—indicates that there is moderate to strong correlations between the two administration periods. Regarding concurrent validity, the BRIEF-2 GEC demonstrates weak to strong correlations with the Child Behavior Checklist (CBCL; $r = .31$ to $.44$), ADHD Rating Scale-IV (ADHD-RS-IV; $r = .50$ to $.79$), Behavior Assessment System for Children, Second Edition-Parent Rating Scale (BASC-2-PRS) indices ($r = -.68$ to $.75$) and Conners Third Edition – Parent Form (Conners 3-P; $r = .22$ to $.56$). It is not surprising that the BRIEF-2 has inconsistent correlations with the various rating scales considering none of them assess specific executive functions. In the
original development of the BRIEF-2, agreement among an expert panel of 12 experienced pediatric neuropsychologists was used to assess the fit of the items within the assessment. Agreement among experts across the items was further assessed using item-total correlations ($r = .44$ to .77) and interrater agreement to judge the conceptual fit. The BRIEF-2 index T-scores (i.e., ERI, BRI, CRI) were used to examine EF skills.

**Conners 3rd Edition, Parent Form (Conners 3P)**

The Conners 3P (Conners, 2008) is a 110-item rating scale used to evaluate symptoms and behaviors of ADHD in children aged 6 to 18 years. The Conners 3P reports 6 primary scales including 2 primary characteristics of ADHD (i.e., inattention and hyperactivity/impulsivity) and 4 ADHD-related challenges (i.e., learning problems, executive functioning, aggression, peer relations). Caregivers rated their child’s behavior based on a Likert scale (i.e., 0 = “not true at all” to 3 = “very much true”). Test-retest analyses – over a 2- to 4-week interval – indicate that the Conners 3 rating form has acceptable reliability ($r = .71$ to .98). Internal consistency ($\alpha = .77$ to .97) also shows that the Conners 3 has good reliability. Caregivers completed the rating form to measure ADHD severity. Conners 3P T-scores from the Inattention and Hyperactivity/Impulsivity subscales were used to examine ADHD symptom severity.

**Wechsler Preschool and Primary Scale of Intelligence, Fourth Edition (WPPSI-IV)**

The WPPSI-IV (Wechsler, 2012) is a measure of intelligence for young children ranging from 2 years, 6 months to 7 years, 7 months. Children were administered the WPPSI-IV by an appropriately trained clinician as part of a comprehensive psychological evaluation to measure their overall cognitive abilities via the FSIQ. The WPPSI-IV has been shown to have adequate reliability based on excellent internal consistency ($\alpha = .96$).
and test-rest validity ($r = .93$) for the FSIQ. Adequate validity has also been found for the WPPSI-IV when compared to its previous version (i.e., WPPSI-III) as strong correlations at the FSIQ-level were demonstrated ($r = .86$). The WPPSI-IV was used to measure children’s level of intelligence as part of a comprehensive evaluation in a university diagnostic clinic. Children’s FSIQ scores were used to examine their level of intellectual functioning.

*Wechsler Intelligence Scale for Children, Fifth Edition (WISC-V)*

The WISC-V (Wechsler, 2014) is a measure of intelligence for children ranging from ages 6 years, 0 months to 16 years, 11 months. Children were administered the WISC-V by a trained researcher or clinician to measure their overall cognitive abilities (i.e., FSIQ). Regarding reliability, internal consistency analyses resulted in good reliability for the FSIQ ($\alpha = .96$ to $.97$). In terms of validity, the WISC-V appears to be measuring intelligence similarly to other cognitive assessments based on its strong correlation with the WISC-IV ($r = .87$). The assessment was used to measure child participants’ level of intelligence in past research studies and as part of a comprehensive evaluation in a university diagnostic clinic. Children’s FSIQ scores were used to examine their intellectual functioning.

*Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV)*

The WAIS-IV (Wechsler, 2008) is an intellectual assessment for adults ranging from 16 years, 0 months to 90 years, 11 months. Trained clinicians administered the WAIS-IV to measure children’s overall cognitive abilities (i.e., FSIQ) as part of comprehensive psychological evaluations. The WAIS-IV has acceptable reliability based on internal consistency (FSIQ: $\alpha = .98$) and test-retest (FSIQ: $r = .96$) analyses.
Furthermore, based on correlations with the WAIS-III, convergent validity was determined to be strong at the FSIQ level ($r = .94$). The assessment was used to measure child participants’ level of intelligence as part of a comprehensive evaluation in a university diagnostic clinic. Children’s FSIQ scores were used to examine intellectual functioning.

**Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II)**

The WASI-II (Wechsler, 2011) is an abbreviated measure of intelligence for individuals ranging from ages 6 years, 0 months to 90 years, 11 months. Reliability analyses indicated that the WASI-II has excellent internal consistency ($\alpha = .96$) for the FSIQ-4 as well as excellent ($\alpha = .94$) test-retest stability for the FSIQ-4. Furthermore, the WASI-II measures intelligence similarly to its previous version (i.e., WASI) based on an excellent correlation ($r = 0.91$). The assessment’s FSIQ-4 was used to measure child participants’ level of intelligence with newly recruited children.

**Procedures**

Prior to data collection, approval from the university institutional review board (IRB) was obtained. Caregivers were required to provide informed consent before completing the study requirements. Additionally, children 7 years and older (or in grades 2 and above) provided assent prior to participation. To ensure study eligibility, caregivers of newly recruited children participated in a phone interview to ensure study eligibility (see Appendix D). The screener questions focused on prior diagnoses, SPED eligibility, academic performance, hearing, and speech-language skills. Children and their caregivers were scheduled for a clinic visit if they met the following criteria: 1) the child is in the designated age range, and 2) the child has a diagnosis and/or SPED classification of
autism. Caregiver informed consent and child assent were obtained before the administration of measures. During the clinic visit, child participants were administered the WASI-II (newly recruited) whereas caregivers completed the following questionnaires: demographics survey, BRIEF-2, Conners 3P, and ASRS. The total visit lasted approximately 60 minutes. Following completion of all study materials, families received a $10 gift certificate, snack, and age-appropriate toy.

Secondary data were collected as part of past research studies and comprehensive psychological evaluations at a university diagnostic clinic. Past research studies followed the same procedure as previously described except for the administration of the WISC-V as opposed to the WASI-II and a different gift card amount. The diagnostic clinic database was developed for clinic purposes by entering de-identified data into a REDCap form. A designated honest broker for data management within the clinic acted as a mediator in filtering and attaining the de-identified data for the research team. As part of clinic policies, data was associated with a unique identifier that only approved clinic personnel could use to identify the data. To ensure that individuals were not represented twice in this research, the clinic-specific unique identifiers were collected when newly recruited children had completed an evaluation through the same clinic where secondary data was being collected. The honest broker filtered the database by study inclusion criteria (i.e., autism diagnosis, children between the ages of 6 and 17 years) as well as used unique identifiers to remove data from children who had previously participated. The database provided by the honest broker included: 1) demographic information (e.g., age of the child at the time of the evaluation, child sex, date of the evaluation, additional diagnoses the child received in addition to autism, family marital status, previous
interventions/therapies), 2) cognitive assessment scores from the WISC-V, WAIS-IV, or WPPSI-IV (depending on the age of the client), and 3) behavior rating scales measuring autism symptoms (i.e., ASRS), ADHD symptoms (i.e., Conners 3P), and executive functioning skills (i.e., BRIEF-2).

**Interrater and Intercoder Reliability**

All researchers (graduate and undergraduate students) directly collecting participant data, including administering either the WISC-V or WASI-II, were required to complete a developmental three-phase training process. In the first stage, researchers attended training focused on the general research session procedures, including background information on the study, measures used in the study, and an overview of the research session checklist (see Appendix E). In the second phase, researchers were trained on the specifics of administering the WASI-II (new recruitment) or WISC-V (previous research studies). During this phase, the lead researcher described and demonstrated administration details (e.g., start points, discontinue rules, standardized scripts, scoring) of the intelligence assessment. Researchers were then required to practice administering the assessment at least once with another researcher.

In the third phase of training, researchers lead a research session with a child while being observed and guided by an advanced graduate researcher who had previously met reliability and completed a graduate-level course focused on the administration and interpretation of several related intellectual assessments (e.g., WISC-V, WAIS-IV, WPPSI-IV). While the researcher administered and scored the intellectual assessment, the advanced graduate researcher observing also scored the assessment. To meet reliability, each researcher was required to score each subtest with at least 80% accuracy (as
compared to the advanced graduate researcher’s scoring). All graduate and undergraduate researchers met reliability with at least 80% accuracy on each subtest during their first research session. Three of the graduate researchers had followed this same training procedure during previous research studies and met reliability with at least 80% accuracy, whereas 2 graduate researchers and 4 undergraduate researchers met reliability for the purposes of this study.

The previous research studies that secondary data was collected followed a similar training procedure and required researchers to meet reliability for the WISC-V with at least 80% accuracy on each subtest. Although the same training procedures were not followed during the diagnostic evaluations (secondary data), graduate-level clinicians and licensed psychologists conducting the psychological evaluations have been appropriately trained on the assessments through coursework and direct supervision.

Two undergraduate researchers served as data entry persons for the data collected from past research studies and newly recruited children. Data entry did not apply to the university clinic data which was provided in a database. All data were entered into a REDCap data entry form by each of the data entry persons from the original electronically generated reports of the WISC-V, WASI-II, ASRS, Conners 3P, and BRIEF-2 resulting in all data being double coded. REDCap has a double-coding function to identify discrepancies between double-coded entries. The first author reviewed and corrected any discrepancies between the entries resulting in 100% agreement on all data entries.

**Data Analysis**
Descriptive statistics were computed to comprehensively describe the sample on which we had complete and incomplete data. Multilevel modeling (MLM; Hox et al., 2017), also known as mixed effects regression or hierarchical linear models (HLM; Raudenbush & Bryk, 2002), was used to determine the impact of ADHD symptom severity, autism symptom severity, and intellectual functioning on the EF of children with autism. To determine how autism symptom severity, ADHD symptom severity, and intellectual functioning impact the EF of children with autism, we used a 2-level multivariate MLM with domain scores of the BRIEF-2 (i.e., ERI, BRI, CRI) as the dependent variable. The lowest level of analysis (Level 1) consisted of the microunits of the domain \( n = 3 \) nested within participants \( n = 65 \), which served as the macrounits of Level 2. Rather than analyzing each of the three domains in isolation and dealing with multiple models with the risk of inflated type one error rates, simultaneously modeling the three domains leveraged the correlation between the domains through the inclusion of random intercepts.

Repeated measures analysis of variance (rmANOVA) is a similar approach; however, the required assumptions of homogeneity of variance and sphericity (Haverkamp & Beauducel, 2017) were suspect in this situation. Additionally, rmANOVA is restricted to the investigation of categorical predictor(s) and the highest level of interaction. While repeated measures analysis of covariance (rmANCOVA) does allow for investigation of a continuous covariance, it may only evaluate main effect roles and not potential moderation effects (Gelman & Hill, 2006). Specifically, fixed main effects and interactions of autism symptom severity (measured by the ASRS), ADHD symptom severity (measured by the Conners 3P), and intellectual functioning (measured by an
individual’s FSIQ on one of the intellectual assessments) were assessed. Of note, FSIQs from the four intelligence assessments (i.e., WPPSI-IV, WISC-V, WAIS-IV, WASI-II) were combined into one variable for the purposes of statistical analyses. No child was administered more than one of the intelligence assessments. Furthermore, child age, sex, and date on which rating scales were completed in relation to COVID-19 (pre- vs. post-March 2020) were included as possible covariates.

A top-down model-building approach and likelihood ratio tests (LRT) were used to determine effect significance and the best-fitting model (Hox et al., 2017). Restricted maximum likelihood (REML) was employed for all modeling, excluding the determination of significance regarding fixed effects (Cheung, 2013). Parameter estimates were tabulated with Wald-type t-tests using the Satterthwaite method for degrees of freedom (Keselman et al., 1999; Satterthwaite, 1946). Visualization of results displays estimated marginal means and corresponding 95% confidence intervals to aid in interpretation. Follow-up pairwise comparisons utilizing Kenward-Rogers degrees of freedom (Kenward & Roger, 1997) were made without controlling for multiple comparisons. Corresponding effect sizes give Cohen’s $d$-like standardized mean differences (SMD) utilizing the standard deviation based on the sum of the MLM variance components (Hedges, 2007).

Missing variables for select child participants resulted in the use of data from 34 of the 65 available child participants when complete case analysis was used. Table 2 displays the number of child participants for whom measures were completed. Specifically, 56 children completed a measure of intellectual functioning, 47 had a complete ASRS (autism symptoms), 50 had a completed Conners 3P (ADHD symptoms),
and 41 had a complete BRIEF-2 (executive functioning). Thirty-four children had all the assessment measures completed as well as demographic covariates. Removing 31 child participants from the dataset due to some level of missing data is problematic in that it increases bias and decreases generalizability. Multiple Imputation (MI) mitigates problems associated with missing data by replacing missing variables with estimations based on covariates (Little & Rubin, 1989). Imputing missing variables with estimated data allows the inclusion of previously removed cases which in turn decreases the likelihood of bias.

To determine whether multiple imputation is appropriate, the context in which data is missing must be assessed. For multiple imputation to be most appropriate, it is recommended that data is “missing at random,” meaning that observed variables impact the reason for which non-variables are missing but the non-observed variables do not influence the missing data. For this study, missing at random was confirmed given the nature of missing data (e.g., participant attrition, assessments were not administered in the diagnostic clinic due to irrelevance for the diagnostic concern). To estimate data, variables in the original data that were not included in the analysis (i.e., auxiliary variables) are used to estimate missing values. For this study, auxiliary variables included child demographics (i.e., sex, age, participation date), recruitment avenue, FSIQ scores, and subtest scores from the BRIEF-2, ASRS, and Conners 3P.

Multiple imputations via chained equations (MICE; Zhang, 2016) uses multivariate data to generate several copies of the datasets (m) where each copy has unique replacement estimates for missing values. In this way, the “correct” value is not “guessed”, but rather the distribution for unknown values is estimated. Each now-
complete copy of the original dataset is individually analyzed, and the set of results is pooled to arrive at a single set of results. For this study, 500 datasets were generated. The MI datasets were similarly analyzed using MLM (as described above) and pooled (Rubin’s Rule). These results are ultimately used for the purposes of this study.

All analyses were conducted in R version 4.2.0 (R Core Team, 2022) and MLM utilized the “lme4” package (Bates et al., 2015). Additionally, the “mice” (Van Buuren & Groothuis-Oudshoorn, 2011) and “mitml” (Grund et al., 2019) were used for multiple imputations. The study defines statistical significance at the .05 level and bidirectional tests unless otherwise stated. All code and full output and included in Appendix F.

Results

Table 3 summarizes parameters estimated by all three MLM models for executive functioning in three domains of (i.e., behavior, emotion, and cognitive regulation), hyperactivity/impulsivity, and social communication deficits. Model A included all independent variables and covariates fit to complete cases only. Nonsignificant variables (i.e., inattention, unusual behaviors, intellectual functioning, child gender, child age, and participation date) were then removed for model B. Lastly, final model refits model B on the MI dataset.

Symptom Severity Predicting Executive Functioning

Interactions were assessed between main effects (i.e., BRIEF-2 domains, hyperactivity/impulsivity, inattention, social communication deficits, unusual behaviors, intellectual functioning) but were all found to be insignificant. Regarding ADHD symptomology, hyperactivity/impulsivity ($b = 3.21, p < .001$) was found to be a
significant predictor of executive functioning suggesting that hyperactivity negatively associated with overall executive functioning in children with autism. Similarly, social communication deficits ($b = 2.26, p = .064$), a core criterion of autism, is positively associated with executive dysfunction at the trend level. Several variables included in the original MLM model with complete-case data including inattention ($b = 0.45, p = .643$), unusual behaviors ($b = 1.96, p = .246$), intellectual functioning ($b = 0.01, p = .898$), child sex ($b = 1.50, p = .458$), child age ($b = 0.40, p = .116$), and participation date ($b = 2.40, p = .100$) were not found to be significant main effects on executive functioning (LRT: model A vs B), $\chi^2(6) = 7.47, p = .280$, and were not included in the final model. See Table 3 for MLM results and Figure 3 for a visual representation of the impact of hyperactivity and social communication deficits on the three domains of executive functioning based on the final model.

**Domains of Executive Functioning**

After controlling for hyperactivity/impulsivity and social communication deficits (between-subject: $SD = 3.52$; cond-ICC = .19), significant differences between the three domains of executive functioning were observed, $F(2, 2983.4) = 9.38, p < .001$. See Table 4 for follow-up pairwise comparisons between the domains of executive functioning, and Figure 4 for a visualization. Emotion regulation skills appeared to be the most impaired ($M = 75.53, 95\% \text{ CI} [73.56, 77.50]$) as compared to child participants’ emotion regulation skills ($M = 69.5, 95\% \text{ CI} [67.54, 71.474]$), $SMD = 0.75, p < .001$, and cognitive regulation skills ($M = 66.55, 95\% \text{ CI} [64.58, 68.51]$), $SMD = 1.12, p < .001$. Conversely, there is no evidence to support a significant difference between behavior regulation and cognitive regulation skills, $SMD = 0.37, p = .934$. Collectively, these
effects account for a large portion of the total variance among executive functioning
domain ratings (multilevel variance partitioning [MVP]): \( r^2 = .34 \).

**Discussion**

The purpose of this study was to examine the EF presentations of autistic children
and how the severity of autism and ADHD symptoms impact EF. Generally, children
demonstrated average intellectual functioning, elevated autism (i.e., social
communication deficits, unusual behaviors) and ADHD symptomology (i.e., inattention,
hyperactivity/impulsivity), and executive dysfunction in the areas of emotion, behavior,
and cognitive regulation.

**Factors Predicting Executive Functioning**

Results suggest that the severity of ADHD and autism symptoms are positively
related to executive dysfunction in autistic children. Specifically,
hyperactivity/impulsivity presented as a significant predictor EF whereas there is no
evidence with this sample that inattention is significant impacts EF. Regarding autism
symptom severity, social communication deficits appear to be negatively associated with
executive dysfunction. However, unusual behaviors, including restricted/repetitive
behaviors, do not appear to be significantly related to EF among autistic children. Lastly,
demographic variables including child gender, child age, and participation date (pre- vs.
post-March 2020) do not appear to be associated with the EF of autistic children. These
results suggest that regardless of the child’s gender, age, and timeline in which EF was
assessed (i.e., pre- or post-March 2020), increased hyperactivity/impulsivity and social
communication deficits result in worsened EF among autistic children. The results of this
study support previous research (e.g., Benallie et al., 2021) suggesting that increased ADHD-related behaviors among autistic children result in worsened EF. However, previous research also suggested a relationship between executive dysfunction and lower intellectual functioning (Benallie et al., 2021), which this study does not support.

**Domains of Executive Functioning**

Emotion, behavior, and cognitive regulation skills are three areas that make up the concept of EF, as theorized by Gioia and colleagues (2015). Although all three areas of EF are clinically impaired with this study’s sample of child participants, differences between the areas of EF emerged. Emotion regulation skills, including shifting and emotion control, emerged as an area of relative weakness. Both behavior (i.e., inhibition, self-monitoring) and cognitive regulation skills (i.e., initiation, working memory, planning/organizing, task-monitoring, organization) appeared to be better developed than the children’s emotion regulation skills though their levels of impairment did not differ from one another. In summary, results suggest that autistic children exhibit more challenges with emotion regulation skills as compared to behavior and cognitive regulation skills. Specifically, difficulties with shifting and emotion control may be more notable. Results support previous research supporting general executive dysfunction among autistic children (e.g., Benallie et al., 2021). This study’s results align with several previous research studies (Corbett et al., 2009; Hill, 2004; Panerai et al., 2014) whose research suggested relative difficulties with shifting. Relative weaknesses with inhibition (i.e., hyperactivity/impulsivity; Corbett et al., 2009) and planning/organizing (Hill, 2004), were not supported by this study.
Clinical Implications

Autistic children not only experience significant social communication/interaction deficits and restricted/repetitive behaviors, but they also demonstrate EF deficits that are commonly associated with other NDDs including ADHD (e.g., Benallie et al., 2021; Corbett et al., 2009; Craig et al., 2015; Hill, 2004, Tye et al., 2014). Overlap in symptomology between autism and ADHD can make it difficult to accurately differentially diagnose NDDs. The results of this study add to the current literature by suggesting that autistic children demonstrate significantly more emotional dysregulation as compared to behavior and cognitive dysregulation. This information can be used to inform differential diagnosis to better diagnose autism in children who also demonstrate symptoms and behaviors associated with other NDDs. Concerning co-occurring diagnoses, these results propose that autistic children who also exhibit significant hyperactivity/impulsivity related to ADHD demonstrate worsened EF skills.

Understanding the EF presentations among autistic children as well as the impact of symptom severity on EF can inform recommendations and targeted intervention goals. Autistic children appear to demonstrate significant executive dysfunction, particularly with regulating emotions. These children would benefit from increased support to learn skills to manage their emotions and inhibit their impulses. Those with increased social communication impairment and co-occurring hyperactivity/impulsivity require more support with everyday responsibilities as EF impacts an individual’s ability to participate socially with others and perform general tasks required to take care of oneself. Targeted treatments may include social skills groups to increase social communication skills, therapies to improve independence and daily living tasks, individual therapy to increase
emotion regulation skills, and behavior management to improve attention and impulse control.

**Limitations and Future Research**

A limitation of this study is the limited number of child participants. The use of MI to impute missing data allowed an additional 24 children to be included in data analysis increasing the statistical power and generalizability of results. Further, the use of MLM analyses, as opposed to rmANCOVA or similar comparison analyses, mitigates the limited number of children by requiring less stringent statistical assumptions. However, due to low child participant numbers, statistical power was not strong enough to run more complex comparative analyses. Future research should separate child participants into groups based on intellectual functioning as well as autism and ADHD symptom severity and compare EF presentations between the groups. Unique EF presentations would further inform differential diagnosis strategies and targeted interventions. Additionally, marked differences between complete-case and MI base analyses emerged (model B vs. final model; see Table 2.3). The incongruence in results indicates a need for further research with more child participants investigating EF presentations among autistic children and co-occurring NDDs.

This study applies broadly to school-aged autistic children. Childhood is developmental in the sense that more complex skills are developed over time, similar to EF skills. With an increased number of children represented across stages of childhood and adolescence, future research may examine how EF presentations compare and evolve across stages of childhood. This information would further inform differential diagnosis for specific ages as well as support targeted intervention goals. Along the same lines,
limited research exists examining EF among young children (<5 years) with autism (Benallie et al., 2021). It is well understood that early identification and intervention for children with ASD provide children with skills to meet their full potential and increase positive outcomes as adults (e.g., Debondance et al., 2017; Hampton & Kaiser, 2016; Peters-Scheffer et al., 2011; Reichow, 2012). Reproducing this study with young children with ASD would be beneficial in determining how executive functioning is impacted among young children with ASD and how that information can be used to inform diagnostic assessment and therapy strategies. A better understanding of EF in young autistic children has the potential to help identify and develop early intervention strategies which could prevent long-term negative effects related to EF.

As part of this study, intellectual functioning did not emerge as a significant variable impacting the severity of executive dysfunction in children with ASD. These results do not align with previous research findings which identified a positive relationship between executive dysfunction and lower intellectual functioning (Blijd-Hoogewys et al., 2014). The lack of significance in this study may be the result of limited children with lower intellectual functioning. Future research examining the relationship between EF and intellectual functioning should ensure the range of IQs is varied and equally distributed across the continuum of intellectual functioning. One way to do this would be to utilize nonverbal IQ assessments and broaden study inclusion criteria to include participants with limited verbal abilities in order to be more inclusive of autistic children with varying levels of functioning.

Another limitation of this study is related to the homogenous sample. The sample of child participants was largely comprised of White ($n = 41, 63.1\%$) males ($n = 47,$
72.3%) in a single community in the mountain west region of the United States. Current prevalence rates of 8-year-old autistic children indicate that approximately 24% are White and 80% are male (Maenner, 2023). The current study’s sample broadly aligns with the general population’s high rates of males diagnosed with autism whereas race/ethnicity is biased. Due to the limited diversity of the sample and the restricted area in which children and their caregivers were recruited, the generalizability of the study results is questionable. However, due to the aligned results between this study and other research studies (e.g., Corbett et al., 2009; Hill, 2004), this study’s results are likely valid. Further research is needed with a larger and more diverse sample to support the results of this study and other similar studies.

Given the differences with symptom presentations between males and females with autism (Young et al., 2018), future research would benefit from further exploring the role of gender on the EF of autistic children. This study did not identify gender as a significant predictor of executive functioning. However, limited females were represented in the sample \( n = 15, 23.1\% \) suggesting bias toward the male autistic profile.

Indirect and performance-based measures of EF often do not produce congruent findings (Benallie et al., 2021; Toplak et al., 2013). However, Miranda and colleagues (2015) indicate that indirect and performance-based assessments of EF are more closely aligned when assessing larger constructs of EF (e.g., emotion regulation index of BRIEF-2) as opposed to areas of EF (e.g., shifting). Therefore, the results of this study are likely generalizable to performance-based assessments commonly used in clinic settings. Further, the ecological validity of indirect assessments suggests that these results
represent the behavioral aspects of EF and how executive dysfunction impacts everyday functioning. To confirm this assumption, future research could answer this study’s research questions using comparable performance-based EF assessments to assess the cognitive aspect of EF and compare the behavioral and cognitive constructs of EF in children with ASD.

Conclusion

Children with NDDs including autism, ADHD, and ID commonly experience executive dysfunction (e.g., Corbett et al., 2009; Hill, 2004; Pitzianti et al., 2016; Tezise et al., 2014) which has the potential to impact their cognitive, academic, social/emotional, and behavioral functioning (Lezak et al., 2012). Previous research has extensively investigated EF in children with ASD (e.g., Benallie et al., 2021; Corbett et al., 2009; Craig et al., 2015; Hill, 2004, Tye et al., 2014). However, limited research has considered how EF is impacted by intellectual functioning as well as ADHD and autism symptom severity (Benallie et al., 2021). This study sought to investigate how autism symptom severity, ADHD symptom severity, and intelligence impact the EF of autistic children. Results suggest that among school-aged autistic children, intellectual functioning does not appear significantly impact EF, but social communication deficits related to autism and hyperactivity/impulsivity related to ADHD negatively predict EF. This study adds to the current research by suggesting that children with ASD experience worsened executive dysfunction as hyperactivity/impulsivity and social communication deficits increase. Due to limitations related to sampling (e.g., number of participants, homogenous sample) further research is necessary with a larger and more diverse sample to confirm these
findings. The literature regarding EF in autistic children would further benefit from targeted age groups as children are consistently developing new and more complex skills which likely contribute to the development of EF skills.
References


without comorbid ADHD-symptoms. *Child and adolescent psychiatry and mental health, 2*(1), 1-12.


### Table 2.1

**Participant Demographics (N = 65)**

<table>
<thead>
<tr>
<th>Child Demographics</th>
<th>M(SD)</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age, years</strong></td>
<td>10.7 (3.2)</td>
<td></td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>15 (23.1)</td>
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</tr>
<tr>
<td>Male</td>
<td>47 (72.3)</td>
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</tr>
<tr>
<td>Not Available</td>
<td>3 (4.6)</td>
<td></td>
</tr>
<tr>
<td><strong>Co-Occurring Diagnoses</strong></td>
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<td>ADHD</td>
<td>30 (46.2)</td>
<td></td>
</tr>
<tr>
<td>ID</td>
<td>6 (9.2)</td>
<td></td>
</tr>
<tr>
<td>SLD</td>
<td>5 (7.7)</td>
<td></td>
</tr>
<tr>
<td>ODD</td>
<td>3 (4.6)</td>
<td></td>
</tr>
<tr>
<td>SMD</td>
<td>2 (3.1)</td>
<td></td>
</tr>
<tr>
<td>Anxiety</td>
<td>13 (20.0)</td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>1 (1.5)</td>
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<tr>
<td><strong>Receiving Special Education Services</strong></td>
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<td></td>
</tr>
<tr>
<td>Yes</td>
<td>40 (61.5)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>24 (36.9)</td>
<td></td>
</tr>
<tr>
<td>Not Available</td>
<td>1 (1.5)</td>
<td></td>
</tr>
<tr>
<td><strong>Previous Mental Health or Behavioral Intervention</strong></td>
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<tr>
<td>Yes</td>
<td>8 (12.3)</td>
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</tr>
<tr>
<td>No</td>
<td>39 (60.0)</td>
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<td><strong>Currently Prescribed Medication</strong></td>
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<tr>
<td>Yes</td>
<td>20 (30.8)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>9 (13.8)</td>
<td></td>
</tr>
<tr>
<td>Not Available</td>
<td>36 (55.4)</td>
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<tr>
<td><strong>Race/Ethnicity</strong></td>
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<td></td>
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<tr>
<td>White</td>
<td>41 (63.1)</td>
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<tr>
<td>Black or African American</td>
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</tr>
<tr>
<td>Hispanic or Latino/a/x/e</td>
<td>3 (4.6)</td>
<td></td>
</tr>
<tr>
<td>Not Available</td>
<td>20 (30.7)</td>
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</table>
### Caregiver Demographics

<table>
<thead>
<tr>
<th>Category</th>
<th>n (%)</th>
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</thead>
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<tr>
<td><strong>Relationship to Child</strong></td>
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</tr>
<tr>
<td>Mother</td>
<td>26 (40.0)</td>
</tr>
<tr>
<td>Father</td>
<td>3 (4.6)</td>
</tr>
<tr>
<td>Not Available</td>
<td>36 (55.4)</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>23 (35.4)</td>
</tr>
<tr>
<td>Male</td>
<td>3 (4.6)</td>
</tr>
<tr>
<td>Not Available</td>
<td>39 (60.0)</td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
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<tr>
<td>Married</td>
<td>39 (60.0)</td>
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<tr>
<td>Single/ Never Married</td>
<td>2 (3.1)</td>
</tr>
<tr>
<td>Divorced or Separated</td>
<td>6 (9.2)</td>
</tr>
<tr>
<td>Other</td>
<td>3 (4.6)</td>
</tr>
<tr>
<td>Not Available</td>
<td>15 (23.1)</td>
</tr>
<tr>
<td><strong>Family Income</strong></td>
<td></td>
</tr>
<tr>
<td>Less than $9,526</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>$9,526-$38,700</td>
<td>7 (10.8)</td>
</tr>
<tr>
<td>$38,701-$82,500</td>
<td>10 (15.4)</td>
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<tr>
<td>$82,501-$157,500</td>
<td>9 (13.8)</td>
</tr>
<tr>
<td>More than $157,500</td>
<td>0 (0.0)</td>
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<tr>
<td>Not Available</td>
<td>39 (60.0)</td>
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<tr>
<td><strong>Education</strong></td>
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<tr>
<td>Less than High School</td>
<td>0 (0.0)</td>
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<tr>
<td>High School Graduate/GED</td>
<td>4 (6.2)</td>
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<tr>
<td>Some College</td>
<td>8 (12.3)</td>
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<tr>
<td>Associate’s Degree</td>
<td>0 (0.0)</td>
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<tr>
<td>Bachelor’s Degree</td>
<td>11 (16.9)</td>
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<tr>
<td>Professional Degree</td>
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<td>Doctorate</td>
<td>1 (1.5)</td>
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<tr>
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<td>39 (60.0)</td>
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<td><strong>Race/Ethnicity</strong></td>
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<tr>
<td>White</td>
<td>25 (38.5)</td>
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<tr>
<td>Hispanic or Latino</td>
<td>1 (1.5)</td>
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<tr>
<td>Other</td>
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<tr>
<td>Not Available</td>
<td>39 (60.0)</td>
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<tr>
<td><strong>Employment</strong></td>
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<tr>
<td>Employed Full Time (40 or more hours per week)</td>
<td>8 (12.3)</td>
</tr>
<tr>
<td>Employed Part Time (Less than 35 hours per week)</td>
<td>5 (7.7)</td>
</tr>
<tr>
<td>Unemployed and Currently Looking for Work</td>
<td>0 (0.0)</td>
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<tr>
<td>Unemployed and Not Currently Looking for Work</td>
<td>1 (1.5)</td>
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<tr>
<td>Student</td>
<td>0 (0.0)</td>
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<tr>
<td>Status</td>
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<tr>
<td>Retired</td>
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<tr>
<td>Homemaker</td>
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<tr>
<td>Unable to Work</td>
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<tr>
<td>Not Available</td>
<td>37</td>
</tr>
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</table>

* Participants were able to choose multiple responses; percentages will not add up to 100%.

a Available for newly recruited participants (n = 18) and those recruited for previous research study #2 (n = 11).

b Available for participants whose data was collected through the university diagnostic clinic (n = 22).

c Available for participants recruited for previous research study #1 (n = 14).
### Table 2.2

**Descriptive Statistics (N = 65)**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Completed Child Participants</th>
<th>Standard Score</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>M (SD)</td>
</tr>
<tr>
<td><strong>Intellectual Functioning</strong></td>
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</tr>
<tr>
<td>WPPSI-IV FSIQ</td>
<td>2</td>
<td>80.0 (5.7)</td>
<td>76 – 84</td>
</tr>
<tr>
<td>WISC-V FSIQ</td>
<td>37</td>
<td>100.5 (19.1)</td>
<td>62 – 135</td>
</tr>
<tr>
<td>WAIS-IV FSIQ</td>
<td>2</td>
<td>97.0 (18.4)</td>
<td>84 – 110</td>
</tr>
<tr>
<td>WASI-II FSIQ-4</td>
<td>15</td>
<td>99.7 (18.4)</td>
<td>59 – 124</td>
</tr>
<tr>
<td>Combined FSIQ</td>
<td>56</td>
<td>99.5 (18.6)</td>
<td>59 – 135</td>
</tr>
<tr>
<td><strong>Autism Symptomology (Autism Spectrum Rating Scales)</strong></td>
<td></td>
<td></td>
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<tr>
<td>Social/Communication</td>
<td>47</td>
<td>66.1 (8.0)</td>
<td>48 – 85</td>
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<tr>
<td>Unusual Behaviors</td>
<td>47</td>
<td>68.1 (5.8)</td>
<td>52 – 79</td>
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<td><strong>ADHD Symptomology (Conners Third Edition)</strong></td>
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<tr>
<td>Inattention</td>
<td>50</td>
<td>73.3 (13.0)</td>
<td>37 – 90</td>
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<tr>
<td>Hyperactivity/Impulsivity</td>
<td>50</td>
<td>77.1 (12.0)</td>
<td>36 – 90</td>
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<td><strong>Executive Functioning (Brief Rating Inventory of Executive Function, Second Edition)</strong></td>
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<tr>
<td>Behavior Regulation Index (BRI)</td>
<td>41</td>
<td>70.7 (9.6)</td>
<td>49 – 86</td>
</tr>
<tr>
<td>Emotion Regulation Index (ERI)</td>
<td>41</td>
<td>76.1 (8.6)</td>
<td>50 – 94</td>
</tr>
<tr>
<td>Cognitive Regulation Index (CRI)</td>
<td>41</td>
<td>66.5 (8.6)</td>
<td>46 – 81</td>
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</table>

*Note.* The standard scores for the WPPSI-IV, WISC-V, WAIS-IV, WASI-II, and combined FSIQ are represented as a composite score, whereas the ASRS, Conners 3P, and BRIEF-2 are T-scores. ASRS = Autism Spectrum Rating Scales; BRIEF-2 = Behavior Rating Inventory of Executive Function, Second Edition; Conners 3P = Conners 3 Parent Assessment Report; FSIQ = Full-Scale Intellectual Quotient; WAIS-IV = Wechsler Adult Intelligence Scale, Fourth Edition; WASI-II = Wechsler Abbreviated Scale of Intelligence, Second Edition; WISC-V = Wechsler Intelligence Scale for
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<tr>
<th>Fixed Effects</th>
<th>Model A</th>
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<td>Intercept</td>
<td>46.32 (5.03)</td>
<td>&lt;.001***</td>
<td>55.24 (2.43)</td>
<td>&lt;.001***</td>
<td>57.52 (3.00)</td>
<td>&lt;.001***</td>
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<td>Domain (ref = Behavior Regulation)</td>
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<td></td>
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<tr>
<td>Emotion Regulation</td>
<td>5.85 (1.52)</td>
<td>&lt;.001***</td>
<td>5.85 (1.52)</td>
<td>&lt;.001***</td>
<td>6.02 (1.89)</td>
<td>.001***</td>
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<tr>
<td>Cognitive Regulation</td>
<td>-4.82 (1.52)</td>
<td>.002**</td>
<td>-4.82 (1.52)</td>
<td>.002**</td>
<td>-2.96 (1.76)</td>
<td>.092</td>
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<td>ADHD Symptom Severity</td>
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<tr>
<td>Hyperactivity/Impulsivity Inattention</td>
<td>2.95 (1.02)</td>
<td>.008**</td>
<td>3.38 (0.62)</td>
<td>&lt;.001***</td>
<td>3.21 (0.73)</td>
<td>&lt;.001***</td>
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</tr>
<tr>
<td>Autism Symptom Severity</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Communication</td>
<td>3.14 (1.29)</td>
<td>.022*</td>
<td>3.84 (1.09)</td>
<td>.001***</td>
<td>2.26 (1.22)</td>
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**Random Effects**

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<td>Residual</td>
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*Note.* Models A and B utilize complete-cases only (*n*= 34), whereas the Final Model is based on 500 multiply imputed datasets (*n*= 65). All three models were fit via REML and *p*-values shown are based on Wald-like t-tests using Satterthwaite’s method for degrees of freedom. BRIEF-2 = Behavior Rating Inventory of Executive Function, Second Edition.

* *p < .05. ** *p < .01. *** *p < .001.
Table 2.4

Follow-up Pairwise Comparisons for the Final MLM for Domains of Executive Functioning (BRIEF-2)

<table>
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<th>Multiple Imputation Data (n = 65)</th>
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<td>0.67 **</td>
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Note. Follow-up pairwise comparisons for BRIEF-2 domains of executive functioning for both complete-case data (n = 41) and multiple imputation data (n = 65) using only significant independent variables (IVs). SMD = Standardized Mean Difference, Cohen’s d-like effect size. BRIEF-2 = Behavior Rating Inventory of Executive Function, Second Edition.

*p < .05. **p < .01. ***p < .001
Figure 2.1.

Model of Executive Functioning Theorized by Gioia and Colleagues (2015)

Note. This study utilizes the model of executive functioning theorized by Gioia and colleagues (2015) via the Behavior Rating Inventory of Executive Function, Second Edition (BRIEF-2).
Figure 2.2.
Flow Diagram of Available Demographic Information

Available Demographic Information

New Recruitment
- Community Recruitment (n = 18)
  - Caregiver
    - Sex
    - Relationship to child
    - Marital Status
    - Income
    - Race/Ethnicity
    - Education
    - Employment
    - Marital Status

Secondary Data
- Past Research Study #1 (n = 11)
- University Clinic Database (n = 22)
  - Caregiver
    - Marital Status
- Past Research Study #2 (n = 14)

Child
- Age
- Sex
- Co-occurring diagnoses
- Race/Ethnicity
- Previous mental health and behavioral services
- SPED services
- Currently taking medication
**Figure 2.3.**

*Impact of Hyperactivity and Social Communication on Domains of Executive Functioning based on Pooled MLM*

The figure displays the impact of hyperactivity and social communication deficits on the domains of executive functioning (i.e., behavior, emotion, and cognitive regulation) at illustration values (Low, Medium, and High based on sample distributions). T-scores (numbers found in parentheses above) associated with levels were chosen based on the individual distribution of scores for the scales of hyperactivity/impulsivity ($M = 77, SD = 12$) and social communication ($M = 66, SD = 8$). Error bands represent +/- 1 standard error for the mean.
Figure 2.4.

*Comparisons of Pooled Estimated Marginal Mean of Executive Functioning (BRIEF-2) by Domains of Behavior, Emotion, and Cognitive Regulation Based on Final MLM Using Multiply Imputed Dataset*

![Graph showing comparisons of pooled estimated marginal mean of executive functioning by domains of behavior, emotion, and cognitive regulation](image)

*Note.* The figure displays the differences between domains of executive functioning, with higher T-scores representing elevated dysfunction. SMD = Standardized Mean Difference, Cohen’s $d$-like effect size. Error bars display 95% confidence intervals for each estimated marginal mean. BRIEF-2 = Behavior Rating Inventory of Executive Function, Second Edition.

***$p < .001$.***
CHAPTER IV
GENERAL SUMMARY AND CONCLUSIONS

Autism is a complex and pervasive neurodevelopmental disorder (NDD) characterized by difficulties with social interactions and communication in addition to restricted/repetitive behaviors (APA, 2013). Everyone with autism is unique and can present with varying levels of symptoms. The presence of co-occurring attention-deficit/hyperactivity disorder (ADHD) and intellectual disability (ID) make the symptom presentation more complex (Grzadzinski et al., 2010; Lecavalier et al., 2011; Mayes et al., 2012; Staikova et al., 2013) resulting in difficulties accurately identifying autism; thus, creating barriers to accessing services. This dissertation aimed to investigate how co-occurring ADHD and ID symptoms impact the executive functioning (EF) of autistic children in hopes to inform differential diagnosis strategies and targeted interventions.

The first study’s purpose was to systematically gather the literature that evaluated EF in children with autism+ADHD and autism+ID to determine the effects of ADHD and ID on the EF of autistic children. The systematic review revealed results across studies are sparse and inconsistent. However, the results provided provisional support for the hypothesis that autistic children experience decreased EF skills when a co-occurring ADHD and/or ID is present. Further, the systematic review supported previous research findings, indicating that the methodological approaches to evaluate EF, specifically performance-based and indirect assessments, are not congruent (Toplak et al., 2013). This further supports the theory that performance-based assessments measure the cognitive
aspect of EF whereas indirect assessments measure the behavioral aspect (Toplak et al., 2013).

The findings from the systematic review informed the directions of the quantitative study which examined EF among school-aged children with ASD using an indirect measure of EF due to its ecological validity (i.e., Behavior Rating Inventory of Executive Function, Second Edition [BRIEF-2]; Gioia et al., 2015). The second study examined how autism symptom severity, ADHD symptom severity, and intellectual functioning impact EF. The results found that EF worsened as social communication deficits and hyperactivity/impulsivity increased. Notably, restricted/repetitive behaviors, inattention, and intellectual functioning were not significant predictors of EF within this sample. When examining EF presentations, results indicated that autistic children demonstrate relative difficulties with emotion regulation as compared to cognitive and behavior regulation skills.

Overall, the two studies comprising this dissertation add to the literature examining EF in autistic children by exploring through a systematic review and quantitative analysis how symptoms of ADHD and ID impact EF. This dissertation also begins to address inconsistencies across research studies concerning the unique EF presentation (relative strengths and weaknesses) of autistic children by using a theoretical model of EF (Gioia et al., 2015) as opposed to looking at individual areas of EF which are known to be correlated and overlapping (e.g., APA, 2013; Craig et al., 2015).

Implications

Understanding the EF presentations of autistic children and related predictive variables has the potential to inform differential diagnosis strategies and intervention
approaches. Children with NDDs including autism, ADHD, and ID often demonstrate overlapping symptoms (e.g., Benallie et al., 2021; Corbett et al., 2009; Craig et al., 2015; Hill, 2004, Tye et al., 2014) making presentations complex and thus requiring further differential diagnostic strategies to clarify appropriate diagnoses. This dissertation provides preliminary evidence for an indirect measure of EF (i.e., BRIEF-2; Gioia et al., 2015) to be used as a differential diagnostic tool. Specifically, it is offered through the dissertation results that autistic children demonstrate increased emotion dysregulation as compared to behavior and cognitive relation. Elevated social communication deficits and hyperactivity/impulsivity further exacerbate executive dysfunction. Regarding intervention, this understanding offers specific areas of EF that may be helpful to be targeted in therapy.

**Future Directions**

Future research directions include further evaluation of the effect of intelligence on the EF of autistic children within a larger and more heterogeneous sample as previous research demonstrates increased executive dysfunction among individuals across the lifespan with autism+ID as compared to ASD only (Benallie et al., 2021; Blijd-Hoogewys et al., 2014). Some research also suggests that higher intelligence acts as a protective factor against executive dysfunction, though this was not conducted with a sample of autistic children (Antshel et al., 2010). Further, given the incongruence between indirect and performance-based measures of EF (Benallie et al., 2021; Toplak et al., 2013), future research may evaluate how autism and ADHD symptom severity predicts the EF of autistic children using performance-based assessments of EF. Lastly, EF is developmental and changes as children age. Examining the EF presentations of
autistic children across various stages of childhood would clarify the development of EF in addition to informing differential diagnosis and targeted treatments by demonstrating stage-specific relative EF strengths and weaknesses.
References


APPENDICES
APPENDIX A

PERMISSION LETTERS
5/19/2023

Dear Tyus Roanhorse:

I am in the process of preparing my dissertation in the psychology department at Utah State University. I hope to complete my degree program in August 2023.

I am requesting your permission to include our published study, "Executive Functioning in Children with ASD+ADHD and ASD+ID: A systematic Review" (published in 2021 in the journal, Research in Autism Spectrum Disorders). I will include acknowledgments and/or appropriate citations to your work in the dissertation. The bibliographic citation will appear in the corresponding dissertation chapter. Please advise me of any changes you require.

Please indicate your approval of this request by signing in the space provided, attaching any other form or instruction necessary to confirm permission. If you have any questions, please call me at the number below.

I hope you will be able to reply immediately.

Thank you for your cooperation,

Kandice Benallie, MS

I hereby give permission to Kandice Benallie to use the following published work in her dissertation.


Signed: ___________________________
5/19/2023

Dear Kaelah Bakner:

I am in the process of preparing my dissertation in the psychology department at Utah State University. I hope to complete my degree program in August 2023.

I am requesting your permission to include our published study, "Executive Functioning in Children with ASD+ADHD and ASD+ID: A systematic Review" (published in 2021 in the journal, Research in Autism Spectrum Disorders). I will include acknowledgments and/or appropriate citations to your work in the dissertation. The bibliographic citation will appear in the corresponding dissertation chapter. Please advise me of any changes you require.

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I hope you will be able to reply immediately.

Thank you for your cooperation,

Kandice Benallie, MS

I hereby give permission to Kandice Benallie to use the following published work in her dissertation.


Signed: ___________________________  5/19/2023
5/19/2023

Dear Jennifer Ha:

I am in the process of preparing my dissertation in the psychology department at Utah State University. I hope to complete my degree program in August 2023.

I am requesting your permission to include our published study, "Executive Functioning in Children with ASD+ADHD and ASD+ID: A systematic Review" (published in 2021 in the journal, Research in Autism Spectrum Disorders). I will include acknowledgments and/or appropriate citations to your work in the dissertation. The bibliographic citation will appear in the corresponding dissertation chapter. Please advise me of any changes you require.

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I hope you will be able to reply immediately.

Thank you for your cooperation.

Kandice Benallie, MS

I hereby give permission to Kandice Benallie to use the following published work in her dissertation.


Signed:  Jennifer Ha
APPENDIX B

DATA COLLECTION AND CODE BOOK
# Data Collection and Code Book

## Ef Asd And Other Ndds Coding Survey

### Identifiers
- **First Author's Last Name**: 
- **Publication Year**: 
- **Journal**
  - (Please write out full journal title - no acronyms)
  - American Journal on Intellectual and Developmental Disabilities
  - Autism
  - Autism Research
  - Autism Research and Treatment
  - Child Neuropsychology
  - Intellectual and Developmental Disabilities
  - Journal of Autism and Developmental Disorders
  - Research in Autism Spectrum Disorders
  - Research in Developmental Disabilities
  - Other

### Demographics
- **Which group does the article analyze?**
  - ASD/ADHD
  - ASD/ID
- **What other diagnostic groups are included in the analyses?**
  - only ASD
  - ADHD
  - ID
  - ASD/ADHD/ID
  - Typically Developing (TD)
  - None
  - Other
  - Other (second other group)

### Other

### Other (second)

### Which type of ADHD was included?
- Inattentive Type
- Hyperactive-Impulsive Type
- Combined Type
- Not specified
- Not applicable
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Are there any additional author locations?
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ASD/ADHD - Average age maximum

ASD/ADHD - Average IQ (in standard score)

ASD/ADHD - IQ minimum

ASD/ADHD - IQ maximum

Total number of ASD/ADHD participants

ASD/ID - Number of Female participants

ASD/ID - Number of Male participants

ASD/ID - Average age (in years)

ASD/ID - Average age minimum

ASD/ID - Average age maximum

ASD/ID - Average IQ (in standard score)

ASD/ID - IQ minimum

ASD/ID - IQ maximum

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Number of Female participants

Number of Male participants

Average age (in years)

Average age minimum

Average age maximum

Average IQ (in standard score)

IQ minimum

IQ maximum

If IQ was assessed, what measure was used to assess IQ?

If IQ was assessed, what was the IQ cut off score for typical intelligence?

Briefly describe the purpose of the study (you can copy and paste study purpose/aims)

List and number the research questions (you can copy and paste)

Copy and paste the abstract
### Executive Functioning

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<tr>
<td>□ Meta-cognition/Cognition Regulation</td>
</tr>
<tr>
<td>□ Behavior Regulation</td>
</tr>
<tr>
<td>□ Overall/Global Executive Functioning</td>
</tr>
<tr>
<td>□ Other</td>
</tr>
</tbody>
</table>

Other: __________

### Measure 1

<table>
<thead>
<tr>
<th>What type of assessment is this measure?</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Direct</td>
</tr>
<tr>
<td>□ Indirect</td>
</tr>
</tbody>
</table>

Direct (requires a clinician to administer the test to an individual)

Indirect (the individual can do it independently - e.g., rating scale, questionnaire)
What wide-range assessment was used (e.g., WISC, NEPSY-2, DKEFS)?

- Behavior Rating Inventory of Executive Function (BRIEF)
- Behavior Rating Inventory of Executive Function, 2nd Edition (BRIEF-2)
- Behavior Assessment System for Children (BASC)
- Behavior Assessment System for Children, 2nd Edition (BASC-2)
- Behavior Assessment System for Children, 3rd Edition (BASC-3)
- Child Behavior Checklist (CBCL)
- Conners Rating Scales (CRS)
- Conners Rating Scale, Revised (CRS-R)
- Conners Rating Scales, 2nd Edition (Conners 2)
- Conners Rating Scales, 3rd Edition (Conners 3)
- Conners Performance Test (CPT)
- Conners Performance Test, 2nd Edition (CPT-2)
- Conners Performance Test, 3rd Edition (CPT-3)
- Delis-Kaplan Executive Function System (D-KEFS)
- A Developmental Neuropsychological Assessment Battery (NEPSY)
- A Developmental Neuropsychological Assessment, 2nd Edition (NEPSY-II)
- Test of Everyday Attention for Children (TEA-Ch)
- Wechsler Intelligence Scale for Children, 3rd Edition (WISC-III)
- Wechsler Intelligence Scale for Children, 4th Edition (WISC-IV)
- Wechsler Intelligence Scale for Children, 5th Edition (WISC-V)
- Wechsler Preschool and Primary Scale of Intelligence, 2nd Edition (WPPSI-II)
- Wechsler Preschool and Primary Scale of Intelligence, 3rd Edition (WPPSI-III)
- Wechsler Preschool and Primary Scale of Intelligence, 4th Edition (WPPSI-IV)
- Wechsler Abbreviated Scale of Intelligence (WASI)
- Other
- Not applicable

Other

What subtest/composite/index was analyzed (from the same wide-range assessment)?

(If not applicable, put "NA")

*If more than one subtest/composite/index was used from the same wide-range assessment, complete a set of questions for each one.*
### What traditional executive functioning assessment was used (e.g., Wisconsin Card Sorting Test)?

- Brixton Spatial Anticipation Test
- Clock Drawing Test
- Design Fluency Test
- Go/NoGo Task
- Grooved Pegboard Test
- Hayling Sentence Completion Test
- Hotel Test
- Iowa Gambling Task
- Letter-Number Span Test
- Multiple Errors Task
- N-back
- Reading Span Test
- Six Elements Test
- Stroop Test
- Sustained Attention to Response Task
- Tapping Test
- Trail Making Test
- Use of Objects and Alternate Uses Test
- Verbal Fluency Test
- Visuospatial Span Task
- Visuospatial Working Memory Test
- Wisconsin Card Sorting Test
- Other
- Not Applicable

**Other**

### What Subtest was analyzed from the traditional assessment?

(If not applicable, put "NA")

(for example, commissions from the corner's performance test would be a "subtest")

*If more than one subtest was used from the same wide-range assessment, complete a set of questions for each one*

### If a rating scale was used, who was the respondent?

- Parent/Caregiver
- Teacher
- Self Report
- Not Applicable

### What area of executive functioning did the measure analyze?

- Initiation
- Planning/Decision Making/Organizing
- Emotion Regulation/Emotional Control
- Cognitive Flexibility/Shifting/Switching
- Self Monitoring
- Initiation
- Working Memory
- Task Monitoring
- Organization of Materials
- Attention
- Meta-cognition/Cognition Regulation
- Behavior Regulation
- Overall/Global Executive Functioning
- [el_other]
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which standardized score was reported?</td>
<td></td>
</tr>
<tr>
<td>- Standard Score</td>
<td></td>
</tr>
<tr>
<td>- Scaled Score</td>
<td></td>
</tr>
<tr>
<td>- T-score</td>
<td></td>
</tr>
<tr>
<td>- Z-score</td>
<td></td>
</tr>
<tr>
<td>- Other</td>
<td></td>
</tr>
<tr>
<td>- A standardized score was not reported</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>What is the score for the only ASD group?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the score for the ASD/ADHD group?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the score for the ADHD group?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the score for the ID group?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
</tbody>
</table>
What is the standard deviation?

What is the percentile rank?
(If not applicable, put "999")

What is the score for the [ASD/ADHD/ID] group?
(If not applicable, put "999")

What is the standard deviation?

What is the percentile rank?
(If not applicable, put "999")

What is the score for the [group_other] group?
(If not applicable, put "999")

What is the standard deviation?

What is the percentile rank?
(If not applicable, put "999")

What is the score for the [group_other_2] group?
(If not applicable, put "999")

What is the standard deviation?

What is the percentile rank?
(If not applicable, put "999")

What is the score for the typically developing group?
(If not applicable, put "999")

What is the standard deviation?

What is the percentile rank?
(If not applicable, put "999")

The following questions ask about the mean/standard deviations for each group.

What variable is the mean/SD about (e.g., errors)?
(If not applicable, put "999")
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the mean for the only ASD group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the ASD/ADHD group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the ADHD group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the ID group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the typically developing group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the [group_other] group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
</tbody>
</table>
What is the mean for the (group_other_2) group?

(If not applicable, put "999")

What is the standard deviation?

(If not applicable, put "999")

Please specify which groups were significantly different, as well as the p-value and effect size.

(Use the format: "ASD < TD", (p-value), (effect size); ASD > TD, (p-value), (effect size)... If not applicable, put "999")

Please list any significant predictors of the area of EF specified for this measure/subtest (separate with commas).

Examples may include: adaptive skills, behavior problems, cognitive/Intelligence, academic achievement

*Regression analysis would have been used to determine this.

Please list any significant constructs that the specified area of EF predicts for this measure/subtest (separate by comma).

Examples may include: adaptive skills, behavior problems, cognitive/Intelligence, academic achievement

*Regression analysis would have been used to determine this.

Please list any significant constructs that are correlated with the specified area of EF (separate by comma).

Examples may include: adaptive skills, behavior problems, cognitive/Intelligence, academic achievement

**Correlation analysis would have been used to determine this.

Was another Assessment/Subtest used to analyze executive functioning?  
☐ Yes  
☐ No

**Measure 2**

What type of assessment is this measure?

☐ Direct  
☐ Indirect

Direct (requires a clinician to administer the test to an individual)  
Indirect (the individual can do it independently - e.g., rating scale, questionnaire)
<table>
<thead>
<tr>
<th>What wide-range assessment was used (e.g., WISC, NEPSY-2, DKIIFS)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>○ Behavior Rating Inventory of Executive Function (BRIEF)</td>
</tr>
<tr>
<td>○ Behavior Rating Inventory of Executive Function, 2nd Edition (BRIEF 2)</td>
</tr>
<tr>
<td>○ Behavior Assessment System for Children (BASC)</td>
</tr>
<tr>
<td>○ Behavior Assessment System for Children, 2nd Edition (BASC-2)</td>
</tr>
<tr>
<td>○ Behavior Assessment System for Children, 3rd Edition (BASC-3)</td>
</tr>
<tr>
<td>○ Child Behavior Checklist (CBCL)</td>
</tr>
<tr>
<td>○ Conners Rating Scales (CRS)</td>
</tr>
<tr>
<td>○ Conners Rating Scale, Revised (CRS-R)</td>
</tr>
<tr>
<td>○ Conners Rating Scales, 2nd Edition (Conners 2)</td>
</tr>
<tr>
<td>○ Conners Rating Scales, 3rd Edition (Conners 3)</td>
</tr>
<tr>
<td>○ Conners Performance Test (CPT)</td>
</tr>
<tr>
<td>○ Conners Performance Test, 2nd Edition (CPT-2)</td>
</tr>
<tr>
<td>○ Conners Performance Test, 3rd Edition (CPT-3)</td>
</tr>
<tr>
<td>○ Delis-Kaplan Executive Function System (DKEFS)</td>
</tr>
<tr>
<td>○ A Developmental Neuropsychological Assessment (NEPSY)</td>
</tr>
<tr>
<td>○ A Developmental Neuropsychological Assessment, 2nd Edition (NEPSY-II)</td>
</tr>
<tr>
<td>○ Test of Everyday Attention for Children (TEA-CH)</td>
</tr>
<tr>
<td>○ Wechsler Intelligence Scale for Children, 3rd Edition (WISC-III)</td>
</tr>
<tr>
<td>○ Wechsler Intelligence Scale for Children, 4th Edition (WISC-IV)</td>
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<tr>
<td>○ Wechsler Intelligence Scale for Children, 5th Edition (WISC-V)</td>
</tr>
<tr>
<td>○ Wechsler Preschool and Primary Scale of Intelligence, 2nd Edition (WPPSI-II)</td>
</tr>
<tr>
<td>○ Wechsler Preschool and Primary Scale of Intelligence, 3rd Edition (WPPSI-III)</td>
</tr>
<tr>
<td>○ Wechsler Preschool and Primary Scale of Intelligence, 4th Edition (WPPSI-IV)</td>
</tr>
<tr>
<td>○ Wechsler Abbreviated Scale of Intelligence (WASI)</td>
</tr>
<tr>
<td>○ Wechsler Abbreviated Scale of Intelligence (WASI-III)</td>
</tr>
<tr>
<td>○ Other</td>
</tr>
<tr>
<td>○ Not applicable</td>
</tr>
</tbody>
</table>

What Subtest/Composite/Index was analyzed (from the wide-range assessment)?

(if not applicable, put "NA")

*If more than one subtest/composite/index was used from the same wide-range assessment, complete a set of questions for each one.*
<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>What traditional executive functioning assessment was used (e.g., Wisconsin Card Sorting Test)?</td>
<td>Brixton Spatial Anticipation Test, Clock Drawing Test, Design Fluency Test, Go/NoGo Task, Greenwich Test, Hayling Sentence Completion Test, Hotel Test, Iowa Gambling Task, Letter-Number Span Test, Multiple Errors Test, N-back, Reading Span Test, Six Elements Test, Stroop Test, Sustained Attention to Response Task, Tinkertoy Test, Trail Making Test, Use of Objects and Alternate Uses Test, Verbal Fluency Test, Visuospatial Span Task, Visuospatial Working Memory Test, Wisconsin Card Sorting Test, Other, Not Applicable</td>
</tr>
<tr>
<td>What Subtest was analyzed from the traditional assessment?</td>
<td>(If not applicable, put &quot;NA&quot;)</td>
</tr>
<tr>
<td>(for example, commissions from the corners performance task would be a &quot;subtest&quot;)</td>
<td></td>
</tr>
<tr>
<td>*If more than one subtest was used from the same wide-range assessment, complete a set of questions for each one</td>
<td></td>
</tr>
<tr>
<td>If a rating scale was used, who was the respondent?</td>
<td>Parent/Caregiver, Teacher, Self Report, Not Applicable</td>
</tr>
<tr>
<td>Question</td>
<td>Option</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Which standardized score was reported?</td>
<td>Standard Score</td>
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<tr>
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<td>Scaled Score</td>
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<td>T-score</td>
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<td>Z-score</td>
</tr>
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<td></td>
<td>Other</td>
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<tr>
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</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>What is the score for the only ASD group?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>What is the score for the ASD/ADHD group?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the standard deviation?</td>
<td></td>
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<td>What is the percentile rank?</td>
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<td>What is the score for the ADHD group?</td>
<td></td>
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<td></td>
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<td>What is the standard deviation?</td>
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<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>What is the score for the ID group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the score for the ASD/ADHD group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the score for the [group_other] group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the score for the [group_other_2] group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the score for the typically developing group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
</tbody>
</table>
The following questions ask about the mean/standard deviations for each group.

What variable is the mean/SD about (e.g., errors)? (If not applicable, put "999")

What is the mean for the only ASD group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the mean for the ASD/ID group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the mean for the ASD/ADHD group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the mean for the ADHD group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the mean for the ID group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the mean for the ASD/ADHD/ID group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the mean for the [group, other] group? (If not applicable, put "999")
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the mean for the [group_other_2] group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the mean for the typically developing group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>Please specify which groups were significantly different</td>
<td></td>
</tr>
<tr>
<td>Please list any significant predictors of the area of EF specified for this measure/substrate (separate with commas)</td>
<td></td>
</tr>
<tr>
<td>Examples may include: adaptive skills, behavior problems, cognitive/intelligence, academic achievement</td>
<td></td>
</tr>
<tr>
<td><strong>Regression analyses would have been used to determine this</strong></td>
<td></td>
</tr>
<tr>
<td>Please list any significant constructs that the specified area of EF predicts for this measure/substrate (separate by comma)</td>
<td></td>
</tr>
<tr>
<td>Examples may include: adaptive skills, behavior problems, cognitive/intelligence, academic achievement</td>
<td></td>
</tr>
<tr>
<td><strong>Regression analyses would have been used to determine this</strong></td>
<td></td>
</tr>
<tr>
<td>Please list any significant constructs that are correlated with the specified area of EF (separate by comma)</td>
<td></td>
</tr>
<tr>
<td>Examples may include: adaptive skills, behavior problems, cognitive/intelligence, academic achievement</td>
<td></td>
</tr>
<tr>
<td><strong>Correlation analyses would have been used to determine this</strong></td>
<td></td>
</tr>
<tr>
<td>Was another Assessment/Subtest used to analyze executive functioning?</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
</tbody>
</table>
### Measure 3

**What type of assessment is this measure?**

- Direct: requires a clinician to administer the test to an individual.
- Indirect: the individual can do it independently (e.g., rating scale, questionnaire).

<table>
<thead>
<tr>
<th>What wide-range assessment was used (e.g., WISC, NEPSY 2, D-KEFS)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>○ Behavior Rating Inventory of Executive Function (BRIEF)</td>
</tr>
<tr>
<td>○ Behavior Rating Inventory of Executive Function, 2nd Edition (BRIEF-2)</td>
</tr>
<tr>
<td>○ Behavior Assessment System for Children (BASC)</td>
</tr>
<tr>
<td>○ Behavior Assessment System for Children, 2nd Edition (BASC-2)</td>
</tr>
<tr>
<td>○ Behavior Assessment System for Children, 3rd Edition (BASC-3)</td>
</tr>
<tr>
<td>○ Child Behavior Checklist (CBCL)</td>
</tr>
<tr>
<td>○ Conners Rating Scales (CRS)</td>
</tr>
<tr>
<td>○ Conners Rating Scales, Revised (CRS-R)</td>
</tr>
<tr>
<td>○ Conners Rating Scales, 2nd Edition (Conners 2)</td>
</tr>
<tr>
<td>○ Conners Rating Scales, 3rd Edition (Conners 3)</td>
</tr>
<tr>
<td>○ Conners Performance Test, 2nd Edition (CPT-2)</td>
</tr>
<tr>
<td>○ Conners Performance Test, 3rd Edition (CPT-3)</td>
</tr>
<tr>
<td>○ D-KEFS: Developmental Neuropsychological Assessment (D-KEFS)</td>
</tr>
<tr>
<td>○ A Developmental Neuropsychological Assessment, 2nd Edition (NEPSY II)</td>
</tr>
<tr>
<td>○ Test of Everyday Attention for Children (TEA-Ch)</td>
</tr>
<tr>
<td>○ Wechsler Intelligence Scale for Children, 3rd Edition (WISC-III)</td>
</tr>
<tr>
<td>○ Wechsler Intelligence Scale for Children, 4th Edition (WISC-IV)</td>
</tr>
<tr>
<td>○ Wechsler Intelligence Scale for Children, 5th Edition (WISC-V)</td>
</tr>
<tr>
<td>○ Wechsler Preschool and Primary Scale of Intelligence, 2nd Edition (WPPSI-II)</td>
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<tr>
<td>○ Wechsler Preschool and Primary Scale of Intelligence, 3rd Edition (WPPSI-III)</td>
</tr>
<tr>
<td>○ Wechsler Preschool and Primary Scale of Intelligence, 4th Edition (WPPSI-IV)</td>
</tr>
<tr>
<td>○ Wechsler Abbreviated Scale of Intelligence (WASI)</td>
</tr>
<tr>
<td>○ Wechsler Abbreviated Scale of Intelligence (WASI-III)</td>
</tr>
<tr>
<td>○ Other</td>
</tr>
<tr>
<td>○ Not applicable</td>
</tr>
</tbody>
</table>

**What Subtest/Composite/Index was analyzed (from the wide-range assessment)?**

*If more than one subtest/composite/index was used from the same wide-range assessment, complete a set of questions for each one.*
What traditional executive functioning assessment was used (e.g., Wisconsin Card Sorting Test)?

- Brixton Spatial Anticipation Test
- Clock Drawing Test
- Design Fluency Test
- Go/NoGo Task
- Greenwich Test
- Hayling Sentence Completion Test
- Hotell Test
- Iowa Gambling Task
- Letter-Number Span Test
- Multiple Errands Test
- N-back
- Reading Span Test
- Six Elements Test
- Stroop Test
- Sustained Attention to Response Task
- Tinkertoy Test
- Trail Making Test
- Use of Objects and Alternate Uses Test
- Verbal Fluency Test
- Visual-Spatial Span Task
- Visual-Spatial Working Memory Test
- Wisconsin Card Sorting Test
- Other
- Not Applicable

Other

What Subtest was analyzed from the traditional assessment?

(If not applicable, put "NA")

*If more than one subtest was used from the same wide-range assessment, complete a set of questions for each one

If a rating scale was used, who was the respondent?

- Parent/Caregiver
- Teacher
- Self-Report
- Not Applicable

What area of executive functioning did the measure analyze?

- Inhibition
- Planning/Decision Making/Organizing
- Emotion Regulation/Emotional Control
- Cognitive Flexibility/Shifting/Switching
- Self Monitoring
- Initiating
- Working Memory
- Task Monitoring
- Organization of Materials
- Attention
- Meta-cognition/Cognition Regulation
- Behavior Regulation
- Overall/Global Executive Functioning
- [Other]
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
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<tbody>
<tr>
<td>Which standardized score was reported?</td>
<td></td>
</tr>
<tr>
<td>☐ Standard Score</td>
<td></td>
</tr>
<tr>
<td>☐ Scaled Score</td>
<td></td>
</tr>
<tr>
<td>☐ T-score</td>
<td></td>
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<tr>
<td>☐ Z-score</td>
<td></td>
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<tr>
<td>☐ Other</td>
<td></td>
</tr>
<tr>
<td>☐ A standardized score was not reported</td>
<td></td>
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<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>What is the score for the ASD group?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
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</tr>
<tr>
<td>What is the score for the ASID/ADHD group?</td>
<td></td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the standard deviation?</td>
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<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the percentile rank?</td>
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</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the score for the ADHD group?</td>
<td></td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the standard deviation?</td>
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<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the percentile rank?</td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the score for the ID group?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
</tbody>
</table>
What is the standard deviation?

What is the percentile rank?

What is the score for the ASD/ADHD/ID group?

What is the standard deviation?

What is the percentile rank?

What is the score for the [group, other] group?

What is the standard deviation?

What is the percentile rank?

What is the score for the [group, other2] group?

What is the standard deviation?

What is the percentile rank?

What is the score for the typically developing group?

What is the standard deviation?

What is the percentile rank?

The following questions ask about the mean/standard deviations for each group.

What variable is the mean/SD about (e.g., errors)?

(If not applicable, put "999")
What is the mean for the ASD group?
(If not applicable, put "999")

What is the standard deviation?
(If not applicable, put "999")

What is the mean for the ASD/ADHD group?
(If not applicable, put "999")

What is the standard deviation?
(If not applicable, put "999")

What is the mean for the ADHD group?
(If not applicable, put "999")

What is the standard deviation?
(If not applicable, put "999")

What is the mean for the ID group?
(If not applicable, put "999")

What is the standard deviation?
(If not applicable, put "999")

What is the mean for the ASD/ADHD/ID group?
(If not applicable, put "999")

What is the standard deviation?
(If not applicable, put "999")

What is the mean for the [group_other] group?
(If not applicable, put "999")

What is the standard deviation?
(If not applicable, put "999")
What is the mean for the [group_other_2] group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the mean for the typically developing group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

Please specify which groups were significantly different. (Use this format: "ASD < ASD/ID (p-value), effect size); ASD > TD (p-value), (effect size)..." If not applicable, put "999")

Please list any significant predictors of the area of EF specified for this measure/subject (separate with commas):

Examples may include: adaptive skills, behavior problems, cognitive/attention, academic achievement

*Regression analyses would have been used to determine this

Please list any significant constructs that the specified area of EF predicts for this measure/subject (separate by comma):

Examples may include: adaptive skills, behavior problems, cognitive/attention, academic achievement

*Regression analyses would have been used to determine this

Please list any significant constructs that are correlated with the specified area of EF (separate by comma):

Examples may include: adaptive skills, behavior problems, cognitive/attention, academic achievement

*Correlation analyses would have been used to determine this

Was another Assessment/Subtest used to analyze executive functioning? ☐ Yes ☐ No
### Measure 4

**What type of assessment is this measure?**
- [ ] Direct: requires a clinician to administer the test to an individual
- [ ] Indirect: the individual can do it independently - e.g., rating scale, questionnaire

**What wide-range assessment was used (e.g., WISC, NEPSY-II, DKEFS)?**
- [ ] Behavior Rating Inventory of Executive Function (BRIEF)
- [ ] Behavior Rating Inventory of Executive Function, 2nd Edition (BRIEF-2)
- [ ] Behavior Assessment System for Children (BASC)
- [ ] Behavior Assessment System for Children, 2nd Edition (BASC-2)
- [ ] Behavior Assessment System for Children, 3rd Edition (BASC-3)
- [ ] Child Behavior Checklist (CBCL)
- [ ] Conners Rating Scales (CRS)
- [ ] Conners Rating Scale: Revised (CRS-R)
- [ ] Conners Rating Scales, 2nd Edition (Conners 2)
- [ ] Conners Rating Scales, 3rd Edition (Conners 3)
- [ ] Conners Performance Test (CPT)
- [ ] Conners Performance Test, 2nd Edition (CPT-2)
- [ ] Conners Performance Test, 3rd Edition (CPT-3)
- [ ] Delis-Kaplan Executive Function System (DKEFS)
- [ ] A Developmental Neuropsychological Assessment (NEPSY)
- [ ] A Developmental Neuropsychological Assessment, 2nd Edition (NEPSY-II)
- [ ] Test of Everyday Attention for Children (TEA-Ch)
- [ ] Wechsler Intelligence Scale for Children, 3rd Edition (WISC-III)
- [ ] Wechsler Intelligence Scale for Children, 4th Edition (WISC-IV)
- [ ] Wechsler Intelligence Scale for Children, 5th Edition (WISC-V)
- [ ] Wechsler Preschool and Primary Scale of Intelligence, 2nd Edition (WPPSI-II)
- [ ] Wechsler Preschool and Primary Scale of Intelligence, 3rd Edition (WPPSI-III)
- [ ] Wechsler Preschool and Primary Scale of Intelligence, 4th Edition (WPPSI-IV)
- [ ] Wechsler Abbreviated Scale of Intelligence (WASI)
- [ ] Other
- [ ] Not applicable

**What Subject/Composite/Index was analyzed (from the wide-range assessment)?**

*If more than one subject/composite/index was used from the same wide-range assessment, complete a set of questions for each one*
What traditional executive functioning assessment was used (e.g., Wisconsin Card Sorting Test)?

- Brixton Spatial Anticipation Test
- Clock Drawing Test
- Design Fluency Test
- Go/NoGo Task
- Greenough Test
- Grayling Sentence Completion Test
- Hotat Test
- Iowa Gambling Task
- Letter Number Span Test
- Multiple Errors Test
- N-back
- Reading Span Test
- Six Elements Test
- Stroop Test
- Sustained Attention to Response Task
- Tactility Test
- Trail Making Test
- Use of Objects and Alternate Uses Test
- Verbal Fluency Test
- Visual Spatial Span Task
- Visuospatial Working Memory Test
- Wisconsin Card Sorting Test
- Other
- Not Applicable

Other

What subtest was analyzed from the traditional assessment?

(for example, commissions from the colored performance test would be a "subtest")

If more than one subtest was used from the same wide-range assessment, complete a set of questions for each one

If a rating scale was used, who was the respondent?

- Parent/Caregiver
- Teacher
- Self-Report
- Not Applicable

What area of executive functioning did the measure analyze?

- Inhibition
- Planning/Decision Making/Organizing
- Emotion Regulation/Emotional Control
- Cognitive Flexibility/Shifting/Switching
- Self Monitoring
- Initiation
- Working Memory
- Task Monitoring
- Organization of Materials
- Attention
- Metacognition/Cognition Regulation
- Behavior Regulation
- Overall (Global Executive Functioning)
- (Other)
<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
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<tbody>
<tr>
<td>Which standardized score was reported?</td>
<td></td>
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<tr>
<td>- Standard Score</td>
<td></td>
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<tr>
<td>- Scaled Score</td>
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<td>- T-score</td>
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<td>- Z-score</td>
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<tr>
<td>- Other</td>
<td></td>
</tr>
<tr>
<td>- A standardized score was not reported</td>
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<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>What is the score for the ASD group?</td>
<td></td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the standard deviation?</td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the percentile rank?</td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the score for the ASD/ADHD group?</td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the standard deviation?</td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the percentile rank?</td>
<td></td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the score for the ADHD group?</td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the standard deviation?</td>
<td></td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>What is the score for the ID group?</td>
<td></td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the standard deviation?</td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the score for the ASD/ADHD/ID group?</td>
<td></td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the score for the [group_other] group?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the score for the [group_other_2] group?</td>
<td></td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the score for the typically developing group?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
<td></td>
</tr>
</tbody>
</table>
What is the percentile rank? (If not applicable, put “999”)

The following questions ask about the mean/standard deviations for each group.

What variable is the mean/SD about (e.g., errors)? (If not applicable, put “999”)

What is the mean for the ASD group? (If not applicable, put “999”)

What is the standard deviation? (If not applicable, put “999”)

What is the mean for the ASD/ID group? (If not applicable, put “999”)

What is the standard deviation? (If not applicable, put “999”)

What is the mean for the ASD/ADHD group? (If not applicable, put “999”)

What is the standard deviation? (If not applicable, put “999”)

What is the mean for the ADHD group? (If not applicable, put “999”)

What is the standard deviation? (If not applicable, put “999”)

What is the mean for the ID group? (If not applicable, put “999”)

What is the standard deviation? (If not applicable, put “999”)

What is the mean for the ASD/ADHD/ID group? (If not applicable, put “999”)

What is the standard deviation? (If not applicable, put “999”)

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What is the mean for the [group other] group?  
(if not applicable, put "999")

What is the standard deviation?  
(if not applicable, put "999")

What is the mean for the [group other 2] group?  
(if not applicable, put "999")

What is the standard deviation?  
(if not applicable, put "999")

What is the mean for the typically developing group?  
(if not applicable, put "999")

What is the standard deviation?  
(if not applicable, put "999")

Please specify which groups were significantly different:  
(use the format: "ASD < TD (p-value), effect size 95")  
(if not applicable, put "999")

Please list any significant predictors of the area of EF specified for this measure/subtest (separate with commas)

Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement

*Regression analyses would have been used to determine this

Please list any significant constructs that the specified area of EF predicts for this measure/subtest (separate by comma)

Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement

*Regression analyses would have been used to determine this
Please list any significant constructs that are correlated with the specified area of EF (separate by comma)

Examples may include: adaptive skills, behavior problems, cognitive abilities, academic achievement

*(If not applicable, put "NA". Put p-value and r in parentheses next to the construct. For example: adaptive skills (p = .002; r = .85))

**Correlation analyses would have been used to determine this

<table>
<thead>
<tr>
<th>Was another Assessment/Subtest used to analyze executive functioning?</th>
</tr>
</thead>
<tbody>
<tr>
<td>○ Yes</td>
</tr>
</tbody>
</table>

**Measure 5**

What type of assessment is this measure?

- ○ Direct
- ○ Indirect

Direct (requires a clinician to administer the test to an individual)
Indirect (the individual can do it independently - e.g., rating scale, questionnaire)
<table>
<thead>
<tr>
<th>What wide-range assessment was used (e.g., WISC, NEPSY-2, DKEFS)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Behavior Rating Inventory of Executive Function (BRIEF)</td>
</tr>
<tr>
<td>- Behavior Rating Inventory of Executive Function, 2nd Edition (BRIEF-2)</td>
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<td>- Behavior Assessment System for Children, 2nd Edition (BASC-2)</td>
</tr>
<tr>
<td>- Behavior Assessment System for Children, 3rd Edition (BASC-3)</td>
</tr>
<tr>
<td>- Conners Rating Scales (CRS)</td>
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<td>- Conners Rating Scale, Revised (CRS-R)</td>
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<td>- Conners Rating Scales, 2nd Edition (Conners 2)</td>
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<td>- Delis-Kaplan Executive Function System (D-KEFS)</td>
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<tr>
<td>- Wechsler Abbreviated Scale of Intelligence (WASI)</td>
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<td>- Wechsler Abbreviated Scale of Intelligence (WASI-2)</td>
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<tr>
<td>- Other</td>
</tr>
<tr>
<td>- Not applicable</td>
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</table>

<table>
<thead>
<tr>
<th>What Subtest/Composite/Index was analyzed (from the wide-range assessment)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>(If not applicable, put &quot;NA&quot;)</td>
</tr>
</tbody>
</table>

* If more than one subtest/composite/index was used from the same wide-range assessment, complete a set of questions for each one.
**What traditional executive functioning assessment was used (e.g., Wisconsin Card Sorting Test)?**

- Boston Spatial Anticipation Test
- Clock Drawing Test
- Design Fluency Test
- Go/NoGo Task
- Greenwich Test
- Hayling Sentence Completion Test
- Hotel Test
- Iowa Gambling Task
- Letter-Number Span Test
- Multiple Errands Test
- N-back
- Reading Span Test
- Six Elements Test
- Spreen Test
- Sustained Attention to Response Task
- Tinkertoy Test
- Trail Making Test
- Use of Objects and Alternate Uses Test
- Verbal Fluency Test
- Visualspatial Span Task
- Visual-spatial Working Memory Test
- Wisconsin Card Sorting Test
- Other
- Not Applicable

**Other**

**What Subtest was analyzed from the traditional assessment?**

(for example, commissions from the corners performance test would be a "subtest").

*If more than one subtest was used from the same wide-range assessment, complete a set of questions for each one*

**If a rating scale was used, who was the respondent?**

- Parent/Caregiver
- Teacher
- Self-Report
- Not Applicable

**What area of executive functioning did the measure analyze?**

- Inhibition
- Planning/Decision Making/Organizing
- Emotion Regulation/Emotional Control
- Cognitive Flexibility/Shifting/Switching
- Self Monitoring
- Initiation
- Working Memory
- Task Monitoring
- Organization of Materials
- Attention
- Metacognition/Cognition Regulation
- Behavior Regulation
- Overall/Global Executive Functioning
- [Ref Other]
Which standardized score was reported?  
- Standard Score  
- Scaled Score  
- T-score  
- Z-score  
- Other  
- A standardized score was not reported

What is the score for the ASD group?  
(if not applicable, put "999")

What is the standard deviation?  
(if not applicable, put "999")

What is the percentile rank?  
(if not applicable, put "999")

What is the score for the ASD/ADHD group?  
(if not applicable, put "999")

What is the standard deviation?  
(if not applicable, put "999")

What is the percentile rank?  
(if not applicable, put "999")

What is the score for the ADHD group?  
(if not applicable, put "999")

What is the standard deviation?  
(if not applicable, put "999")

What is the percentile rank?  
(if not applicable, put "999")
What is the score for the ID group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the percentile rank? (If not applicable, put "999")

What is the score for the ASID/ADHD/ID group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the percentile rank? (If not applicable, put "999")

What is the score for the [group_1] group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the percentile rank? (If not applicable, put "999")

What is the score for the [group_2] group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the percentile rank? (If not applicable, put "999")

What is the score for the typically developing group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>The following questions ask about the mean/standard deviations for each group.</td>
<td></td>
</tr>
<tr>
<td>What variable is the mean/SD about (e.g., errors)?</td>
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<td>What is the standard deviation?</td>
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<tr>
<td>What is the mean for the ASD/ID group?</td>
<td></td>
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<tr>
<td>What is the standard deviation?</td>
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</tr>
<tr>
<td>What is the mean for the ASD/ADHD group?</td>
<td></td>
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<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the mean for the ADHD group?</td>
<td></td>
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<tr>
<td>What is the standard deviation?</td>
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<tr>
<td>What is the mean for the ID group?</td>
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<td>What is the standard deviation?</td>
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<tr>
<td>What is the mean for the ASD/ADHD/ID group?</td>
<td></td>
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<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
</tbody>
</table>
What is the mean for the [group other] group?

(If not applicable, put "999")

What is the standard deviation?

(If not applicable, put "999")

What is the mean for the [group other 2] group?

(If not applicable, put "999")

What is the standard deviation?

(If not applicable, put "999")

What is the mean for the typically developing group?

(If not applicable, put "999")

What is the standard deviation?

(If not applicable, put "999")

Please specify which groups were significantly different

(Use this format: "ASD < AS&D; p-value, (effect size); ASD > TD (p-value), (effect size)..." If not applicable, put "999")

Please list any significant predictors of the area of EF specified for this measure/subtest (separate with commas)

Examples may include adaptive skills, behavior problems, cognitive intelligence, academic achievement

**Regression analyses would have been used to determine this

Please list any significant constructs that the specified area of EF predicts for this measure/subtest (separate by comma)

Examples may include adaptive skills, behavior problems, cognitive intelligence, academic achievement

**Regression analyses would have been used to determine this
Please list any significant constructs that are correlated with the specified area of EF (separate by commas).

Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement. **(If not applicable, put "NA". Put p-value and r in parentheses next to the construct. For example: adaptive skills (p = .002; r = .35).)**

**Covariates** used to determine this:

Was another Assessment/Subtest used to analyze executive functioning?

- Yes
- No

**Measure 6**

What type of assessment is this measure?

- Direct
- Indirect

Direct (requires a clinician to administer the test to an individual)

Indirect (the individual can do it independently - e.g., rating scale, questionnaire)
What wide-range assessment was used (e.g., WISC, NEPSY 2, D-KEFS)?

- Behavior Rating Inventory of Executive Function (BRIEF)
- Behavior Rating Inventory of Executive Function, 2nd Edition (BRIEF 2)
- Behavior Assessment System for Children (BASC)
- Behavior Assessment System for Children, 2nd Edition (BASC 2)
- Behavior Assessment System for Children, 3rd Edition (BASC 3)
- Child Behavior Checklist (CBCL)
- Conners Rating Scales (CRS)
- Conners Rating Scale, Revised (CRS-R)
- Conners Rating Scales, 2nd Edition (Conners 2)
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- Conners Performance Test (CPT)
- Conners Performance Test, 2nd Edition (CPT 2)
- Conners Performance Test, 3rd Edition (CPT 3)
- Delis-Kaplan Executive Function System (D-KEFS)
- A Developmental Neuropsychological Assessment (NEPSY)
- A Developmental Neuropsychological Assessment, 2nd Edition (NEPSY-II)
- Test of Everyday Attention for Children (TEA-Ch)
- Wechsler Intelligence Scale for Children, 3rd Edition (WISC-III)
- Wechsler Intelligence Scale for Children, 4th Edition (WISC-IV)
- Wechsler Intelligence Scale for Children, 5th Edition (WISC-V)
- Wechsler Preschool and Primary Scale of Intelligence, 2nd Edition (WPPSI-II)
- Wechsler Preschool and Primary Scale of Intelligence, 3rd Edition (WPPSI-III)
- Wechsler Preschool and Primary Scale of Intelligence, 4th Edition (WPPSI-IV)
- Wechsler Abbreviated Scale of Intelligence (WASI)
- Wechsler Abbreviated Scale of Intelligence (WASI-II)
- Other
- Not applicable

What Subtest/Composite/Index was analyzed (from the wide-range assessment)?

(If not applicable, put "NA")

*If more than one subtest/composite/index was used from the same wide-range assessment, complete a set of questions for each one*
What traditional executive functioning assessment was used (e.g., Wisconsin Card Sorting Test)?

- Brixton Spatial Anticipation Test
- Clock Drawing Test
- Design Fluency Test
- Go/NoGo Task
- Grooved Pegboard Test
- Halstead-Reitan Tests
- Incomplete Sentences Completion Test
- Iowa Gambling Task
- Letter-Number Span Test
- Multiple Errors Test
- N-back
- Reading Span Test
- Six Elements Test
- Stroop Test
- Sustained Attention to Response Task
- Tapping Test
- Trail Making Test
- Use of Objects and Alternate Uses Test
- Verbal Fluency Test
- Visuospatial Span Task
- Visual-Spatial Working Memory Test
- Wisconsin Card Sorting Test
- Other
- Not Applicable

Other

What subtest was analyzed from the traditional assessment?

(if not applicable, put "NA")

*(If more than one subtest was used from the same wide-range assessment, complete a set of questions for each one)*

If a rating scale was used, who was the respondent?

- Parent/Caregiver
- Teacher
- Self-Report
- Not Applicable

What area of executive functioning did the measure analyze?

- Inhibition
- Planning/Decision Making/Organizing
- Emotion Regulation/Emotional Control
- Cognitive Flexibility/Shifting/Switching
- Self-Monitoring
- Initiating
- Working Memory
- Task Monitoring
- Organization of Materials
- Attention
- Meta-cognition/Cognition Regulation
- Behavior Regulation
- Overall/Global Executive Functioning
- [if other]
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which standardized score was reported?</td>
<td></td>
</tr>
<tr>
<td>□ Standard Score</td>
<td></td>
</tr>
<tr>
<td>□ Scaled Score</td>
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<td>□ T-score</td>
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<td>□ Z-score</td>
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<tr>
<td>□ Other</td>
<td></td>
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<tr>
<td>□ A standardized score was not reported</td>
<td></td>
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<tr>
<td>Other</td>
<td></td>
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<tr>
<td>What is the score for the ASD group?</td>
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<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the standard deviation?</td>
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<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the percentile rank?</td>
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<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the score for the ASD/ADHD group?</td>
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<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the standard deviation?</td>
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<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the score for the ADHD group?</td>
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<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the standard deviation?</td>
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<td>What is the percentile rank?</td>
<td></td>
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<tr>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>Question</td>
<td>Response</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>What is the score for the ID group?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the score for the ASD/ADHD/ID group?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
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</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the score for the [group_other] group?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the score for the [group_other_2] group?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the score for the typically developing group?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>The following questions ask about the mean/standard deviations for each group.</td>
<td></td>
</tr>
<tr>
<td>What variable is the mean/SD about (e.g., errors)?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the ASD group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the ASD/ADHD group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the ADHD group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the ID group?</td>
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</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the ASD/ADHD/ID group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>What is the mean for the [group_other] group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the [group_other_2] group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the typically developing group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>Please specify which groups were significantly different</td>
<td>(Use this format: &quot;ASD &lt; TD (p-value), (effect size); ASD &gt; TD (p-value), (effect size)...&quot; If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>Please list any significant predictors of the area of EF specified for this measure/subject (separate with commas)</td>
<td>(If not applicable, put &quot;NA&quot;. Put p-value in parentheses next to the construct. For example: adaptive skills (p = .002))</td>
</tr>
<tr>
<td>Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement</td>
<td><strong>Regression analyses would have been used to determine this</strong></td>
</tr>
<tr>
<td>Please list any significant constructs that the specified area of EF predicts for this measure/subject (separate by comma)</td>
<td>(If not applicable, put &quot;NA&quot;. Put p-value in parentheses next to the construct. For example: adaptive skills (p = .002))</td>
</tr>
<tr>
<td>Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement</td>
<td><strong>Regression analyses would have been used to determine this</strong></td>
</tr>
</tbody>
</table>
Confidential

Please list any significant constructs that are correlated with the specified area of EF (separate by comma).

Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement. (If not applicable, put "NA". Put p-value and r in parentheses next to the construct. For example: adaptive skills (p = .002; r = .85)).

**Correlation analyses would have been used to determine this.

Was another Assessment/Subtest used to analyze executive functioning?  
☐ Yes  
☐ No

Measure 7

What type of assessment is this measure?  
☐ Direct  
☐ Indirect

Direct (requires a clinician to administer the test to an individual)  
Indirect (the individual can do it independently - e.g., rating scale, questionnaire)
What wide-range assessment was used (e.g., WISC, NEPSY-II, D-KEFS)?

- Behavior Rating Inventory of Executive Function (BRIEF)
- Behavior Rating Inventory of Executive Function, 2nd Edition (BRIEF-2)
- Behavior Assessment System for Children (BASC)
- Behavior Assessment System for Children, 2nd Edition (BASC-2)
- Behavior Assessment System for Children, 3rd Edition (BASC-3)
- Child Behavior Checklist (CBCL)
- Conners Rating Scales (CRS)
- Conners Rating Scale, Revised (CRS-R)
- Conners Rating Scales, 2nd Edition (Conners 2)
- Conners Rating Scales, 3rd Edition (Conners 3)
- Conners Performance Test (CPT)
- Conners Performance Test, 2nd Edition (CPT-2)
- Conners Performance Test, 3rd Edition (CPT-3)
- Delin-Kaplan Executive Function System (D-KEFS)
- A Developmental Neuropsychological Assessment (NEPSY)
- A Developmental Neuropsychological Assessment, 2nd Edition (NEPSY-II)
- Test of Everyday Attention for Children (TEA-CH)
- Wechsler Intelligence Scale for Children, 3rd Edition (WISC-III)
- Wechsler Intelligence Scale for Children, 4th Edition (WISC-IV)
- Wechsler Intelligence Scale for Children, 5th Edition (WISC-V)
- Wechsler Preschool and Primary Scale of Intelligence, 2nd Edition (WPPSI-II)
- Wechsler Preschool and Primary Scale of Intelligence, 3rd Edition (WPPSI-III)
- Wechsler Preschool and Primary Scale of Intelligence, 4th Edition (WPPSI-IV)
- Wechsler Abbreviated Scale of Intelligence (WASI)
- Wechsler Abbreviated Scale of Intelligence (WASI-III)
- Other
- Not applicable

What Subtest/Composite/Index was analyzed (from the wide-range assessment)?

*If not applicable, put “NA”*

*If more than one subtest/composite/index was used from the same wide-range assessment, complete a set of questions for each one*
**What traditional executive functioning assessment was used (e.g., Wisconsin Card Sorting Test)?**

- Brinon Spatial Anticipation Test
- Clock Drawing Test
- Design Fluency Test
- Go/NoGo Task
- Greenwich Test
- Halving Sentence Completion Test
- Hotel Test
- Iowa Gambling Task
- Letter Number Span Test
- Multiple Endings Test
- N-back
- Reading Span Test
- Six Elements Test
- Group Test
- Sustained Attention to Response Task
- Timerkey Test
- Trail Making Test
- Use of Objects and Alternate Uses Test
- Verbal Fluency Test
- Visual Spatial Span Task
- Visuospatial Working Memory Test
- Wisconsin Card Sorting Test
- Other
- Not Applicable

*Other_

**What subtest was analyzed from the traditional assessment?**

(If not applicable, put "NA")

*If more than one subtest was used from the same wide-range assessment, complete a set of questions for each one*

**If a rating scale was used, who was the respondent?**

- Parent/Caregiver
- Teacher
- Self-Report
- Not Applicable

**What area of executive functioning did the measure analyze?**

- inhibition
- Planning/Decision Making/Organizing
- Emotion Regulation/Emotional Control
- Cognitive Flexibility/Shifting/Switching
- Self-Monitoring
-Initiating
- Working Memory
- Task Monitoring
- Organization of Materials
- Attention
- Meta-cognition/Cognitive Regulation
- Behavior Regulation
- Overall/Global Executive Functioning
- [Other]
<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
<th>Other</th>
<th>Score for ASD group</th>
<th>Standard deviation</th>
<th>Percentile rank</th>
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<tr>
<td>Which standardized score was reported?</td>
<td>Standard Score</td>
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<td>Scaled Score</td>
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<td>T-score</td>
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<td></td>
<td>Z-score</td>
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<td></td>
<td>Other</td>
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<td>A standardized score was not reported</td>
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<tr>
<td>What is the score for the ASD group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
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<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the score for the ASD/ADHD group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
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<td>What is the score for the ADHD group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
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<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
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<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
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<td>Question</td>
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<td>-------------------------------------------------------------------------</td>
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<tr>
<td>What is the score for the ID group?</td>
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<td>What is the score for the ASD/ADHD/ID group?</td>
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<tr>
<td>What is the percentile rank?</td>
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<tr>
<td>What is the score for the [group_other] group?</td>
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<tr>
<td>What is the standard deviation?</td>
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<tr>
<td>What is the score for the [group_other_2] group?</td>
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<tr>
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<td>What is the score for the typically developing group?</td>
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<td></td>
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<tr>
<td>What is the standard deviation?</td>
<td></td>
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</tr>
</tbody>
</table>
What is the percentile rank? [If not applicable, put "999"]

The following questions ask about the mean/standard deviations for each group.

What variable is the mean/SD about (e.g., errors)? [If not applicable, put "999"]

What is the mean for the ASD group? [If not applicable, put "999"]

What is the standard deviation? [If not applicable, put "999"]

What is the mean for the ASD/AD group? [If not applicable, put "999"]

What is the standard deviation? [If not applicable, put "999"]

What is the mean for the ASD/ADHD group? [If not applicable, put "999"]

What is the standard deviation? [If not applicable, put "999"]

What is the mean for the ADHD group? [If not applicable, put "999"]

What is the standard deviation? [If not applicable, put "999"]

What is the mean for the ID group? [If not applicable, put "999"]

What is the standard deviation? [If not applicable, put "999"]

What is the mean for the ASD/ADHD/ID group? [If not applicable, put "999"]

What is the standard deviation? [If not applicable, put "999"]
What is the mean for the [group other] group?
(If not applicable, put "999")

What is the standard deviation?
(If not applicable, put "999")

What is the mean for the [group other 2] group?
(If not applicable, put "999")

What is the standard deviation?
(If not applicable, put "999")

What is the mean for the typically developing group?
(If not applicable, put "999")

What is the standard deviation?
(If not applicable, put "999")

Please specify which groups were significantly different
(Use this format: "ASD < TD (p-value), effect size: ASD > TD (p-value), (effect size)"
If not applicable, put "999")

Please list any significant predictors of the area of EF specified for this measure/subtest (separate with commas)
Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement
*Regression analyses would have been used to determine this

Please list any significant constructs that the specified area of EF predicts for this measure/subtest (separate by comma)
Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement
*Regression analyses would have been used to determine this
Please list any significant constructs that are correlated with the specified area of EF (separate by comma).
Examples may include: adaptive skills, behavior problems, cognitive/intelligence, academic achievement.

**Correlation analyses would have been used to determine this.**

Was another Assessment/Subtest used to analyze executive functioning?
- Yes
- No

**Measure 8**

What type of assessment is this measure?
- Direct
- Indirect

Direct (requires a clinician to administer the test to an individual).
Indirect (the individual can do it independently - e.g., rating scale, questionnaire).
What wide-range assessment was used (e.g., WISC, NEPSY-2, DKF5)?

- Behavior Rating Inventory of Executive Function (BRIEF)
- Behavior Rating Inventory of Executive Function, 2nd Edition (BRIEF 2)
- Behavior Assessment System for Children (BASC)
- Behavior Assessment System for Children, 2nd Edition (BASC-2)
- Behavior Assessment System for Children, 3rd Edition (BASC-3)
- Conners' Rating Scales (CRS)
- Conners Rating Scale, Revised (CRS-R)
- Conners Rating Scales, 2nd Edition (Conners 2)
- Conners Rating Scales, 3rd Edition (Conners 3)
- Conners Performance Test (CPT)
- Conners Performance Test, 2nd Edition (CPT-2)
- Conners Performance Test, 3rd Edition (CPT-3)
- Delis-Kaplan Executive Function System (D-KEFS)
- A Developmental Neuropsychological Assessment (NEPSY)
- A Developmental Neuropsychological Assessment, 2nd Edition (NEPSY-II)
- Test of Everyday Attention for Children (TEA-CH)
- Wechsler Intelligence Scale for Children, 3rd Edition (WISC-III)
- Wechsler Intelligence Scale for Children, 4th Edition (WISC-IV)
- Wechsler Intelligence Scale for Children, 5th Edition (WISC-V)
- Wechsler Preschool and Primary Scale of Intelligence, 2nd Edition (WPPSI-II)
- Wechsler Preschool and Primary Scale of Intelligence, 3rd Edition (WPPSI-III)
- Wechsler Preschool and Primary Scale of Intelligence, 4th Edition (WPPSI-IV)
- Wechsler Abbreviated Scale of Intelligence (WASI)
- Wechsler Abbreviated Scale of Intelligence (WASI-II)
- Other
- Not applicable

Other

What Subtest/Composite/Index was analyzed (from the wide-range assessment)?

*If more than one subtest/composite/index was used from the same wide-range assessment, complete a set of questions for each one*
What traditional executive functioning assessment was used (e.g., Wisconsin Card Sorting Test)?

- Brixton Spatial Anticipation Test
- Clock Drawing Test
- Design Fluency Test
- Go/NoGo Task
- Graduate Test
- Hayling Sentence Completion Test
- Hotel Test
- Iowa Gambling Task
- Letter-Number Span Test
- Multiple Endpoints Test
- N-back
- Reading Span Test
- Six Elements Test
- Stroop Test
- Sustained Attention to Response Task
- Trinket Test
- Trail Making Test
- Use of Objects and Alternate Uses Test
- Verbal Fluency Test
- Visual-Spatial Span Task
- Visual-Spatial Working Memory Test
- Wisconsin Card Sorting Test
- Other
- Not Applicable

Other

What Subtest was analyzed from the traditional assessment?

(for example, commissions from the corners performance test would be a "subtest")

*If more than one subtest was used from the same wide range assessment, complete a set of questions for each one*

If a rating scale was used, who was the respondent?

- Parent/Caregiver
- Teacher
- Self-Report
- Not Applicable

What area of executive functioning did the measure analyze?

- Inhibition
- Planning/Decision Making/Organizing
- Emotion Regulation/Emotional Control
- Cognitive Flexibility/Shifting/Switching
- Self Monitoring
- Initiating
- Working Memory
- Task Monitoring
- Organization of Materials
- Attention
- Meta-cognition/Cognition Regulation
- Behavior Regulation
- Overall/Global Executive Functioning
- Other
<table>
<thead>
<tr>
<th>Question</th>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which standardized score was reported?</td>
<td>Standard Score</td>
</tr>
<tr>
<td></td>
<td>Scaled Score</td>
</tr>
<tr>
<td></td>
<td>T-score</td>
</tr>
<tr>
<td></td>
<td>Z-score</td>
</tr>
<tr>
<td></td>
<td>Other</td>
</tr>
<tr>
<td></td>
<td>A standardized score was not reported</td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>What is the score for the ASD group?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the score for the ASD/ADHD group?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the score for the ADHD group?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>Question</td>
<td>Value</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>What is the score for the ID group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the score for the ASD/ADHD-ID group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the score for the [group_other] group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the score for the [group_other_2] group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the score for the typically developing group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
</tbody>
</table>
What is the percentile rank?

The following questions ask about the mean/standard deviations for each group.

What variable is the mean/SD about (e.g., errors)?

What is the mean for the ASD group?

What is the standard deviation?

What is the mean for the ASD/AD group?

What is the standard deviation?

What is the mean for the ASD/ADHD group?

What is the standard deviation?

What is the mean for the ADHD group?

What is the standard deviation?

What is the mean for the ID group?

What is the standard deviation?

What is the mean for the ASD/ADHD/ID group?

(If not applicable, put "999")
### What is the standard deviation?

(If not applicable, put "999")

### What is the mean for the (group other) group?

(If not applicable, put "999")

### What is the standard deviation?

(If not applicable, put "999")

### What is the mean for the (group other 2) group?

(If not applicable, put "999")

### What is the standard deviation?

(If not applicable, put "999")

### What is the mean for the typically developing group?

(If not applicable, put "999")

### What is the standard deviation?

(If not applicable, put "999")

#### Please specify which groups were significantly different

(Use this format: "ASD < TD (p-value), (effect size); ASD > TD (p-value), (effect size)...." If not applicable, put "999")

#### Please list any significant predictors of the area of EF specified for this measure/subtest (separate with commas)

Examples may include: adaptive skills, behavior problems, cognitive/clinical, academic achievement

*Regression analyses would have been used to determine this*

#### Please list any significant constructs that the specified area of EF predicts for this measure/subtest (separate by comma)

Examples may include: adaptive skills, behavior problems, cognitive/clinical, academic achievement

*Regression analyses would have been used to determine this*
Please list any significant constructs that are correlated with the specified area of EF (separate by comma)

Examples may include: adaptive skills, behavior problems, cognitive/intelligence, academic achievement

(If not applicable, put "NA". Put p-value and r in parentheses next to the construct. For example: adaptive skills (p = .002; r = .80))

**Correlation analyses would have been used to determine this**

Was another Assessment/Subtest used to analyze executive functioning?

□ Yes
□ No

**Measure 9**

What type of assessment is this measure?

□ Direct
□ Indirect

Direct (requires a clinician to administer the test to an individual)

Indirect (the individual can do it independently - e.g. rating scale, questionnaire)
What wide-range assessment was used (e.g., WISC, NEPSY-2, BRIEF)?

- Behavior Rating Inventory of Executive Function (BRIEF)
- Behavior Assessment System for Children, 2nd Edition (BASC-2)
- Child Behavior Checklist (CBCL)
- Conners Rating Scales (CRS)
- Conners Rating Scale, Revised (CRS-R)
- Conners Rating Scales, 2nd Edition (Conners 2)
- Other
- Not applicable

What Subtest/Composite/Index was analyzed (from the wide-range assessment)?

(If not applicable, put "NA")

*If more than one subtest/composite/index was used from the same wide-range assessment, complete a set of questions for each one.*
What traditional executive functioning assessment was used (e.g., Wisconsin Card Sorting Test)?

- Bratton Spatial Anticipation Test
- Clock Drawing Test
- Design Fluency Test
- Go/NoGo Task
- Greenwich Test
- Hayling Sentence Completion Test
- Hotel Test
- Iowa Gambling Task
- Letter-Number Span Test
- Multiple Errors Test
- N-back
- Reading Span Test
- Six Elements Test
- Span Test
- Sustained Attention to Response Task
- Tinkertoy Test
- Trail Making Test
- Use of Objects and Alternate Uses Test
- Verbal Fluency Test
- Visual-Spatial Span Task
- Visual-Spatial Working Memory Test
- Wisconsin Card Sorting Test
- Other
- Not Applicable

Other

What Subtest was analyzed from the traditional assessment? (for example, commissions from the corners performance test would be a “subtest.”)

*If more than one subtest was used from the same wide-range assessment, complete a set of questions for each one

If a rating scale was used, who was the respondent?

- Parent/Caregiver
- Teacher
- Self-Report
- Not Applicable

What area of executive functioning did the measure analyze?

- Inhibition
- Planning/Decision Making/Organizing
- Emotion Regulation/Emotional Control
- Cognitive Flexibility/Shifting/Switching
- Self Monitoring
- Initiating
- Working Memory
- Task Monitoring
- Organization of Materials
- Attention
- Meta-cognition/Cognition Regulation
- Behavior Regulation
- Overall/Global Executive Functioning
- [ref_other]
Which standardized score was reported?  
- Standard Score  
- Scaled Score  
- T-score  
- Z-score  
- Other  
- A standardized score was not reported  

Other  

What is the score for the ASD group?  
(If not applicable, put "999")  

What is the standard deviation?  
(If not applicable, put "999")  

What is the percentile rank?  
(If not applicable, put "999")  

What is the score for the ASD/ADHD group?  
(If not applicable, put "999")  

What is the standard deviation?  
(If not applicable, put "999")  

What is the percentile rank?  
(If not applicable, put "999")  

What is the score for the ASD/ADHD group?  
(If not applicable, put "999")  

What is the standard deviation?  
(If not applicable, put "999")  

What is the percentile rank?  
(If not applicable, put "999")  

What is the score for the ADHD group?  
(If not applicable, put "999")  

What is the standard deviation?  
(If not applicable, put "999")  

What is the percentile rank?  
(If not applicable, put "999")
What is the score for the ID group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the percentile rank? (If not applicable, put "999")

What is the score for the ASD/ADHD/ID group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the percentile rank? (If not applicable, put "999")

What is the score for the [group_other] group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the percentile rank? (If not applicable, put "999")

What is the score for the [group_other_2] group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the percentile rank? (If not applicable, put "999")

What is the score for the typically developing group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")
<table>
<thead>
<tr>
<th>Question</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>The following questions ask about the mean/standard deviations for each group.</td>
<td></td>
</tr>
<tr>
<td>What variable is the mean/SD about (e.g., errors)?</td>
<td></td>
</tr>
<tr>
<td>What is the mean for the ASD group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the mean for the ASD/ADHD group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the mean for the ADHD group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the mean for the ID group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the mean for the ASD/ADHD/ID group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>What is the mean for the [group_1] group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the [group_2] group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the typically developing group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
</tbody>
</table>

Please specify which groups were significantly different:

(Use this format: "ASD < ASDD (p-value), (effect size); ASD > TD (p-value), (effect size)"). If not applicable, put "999")

Please list any significant predictors of the area of EF specified for this measure/subtest (separate with commas):

Examples may include: adaptive skills, behavior problems, cognitive/intelligence, academic achievement

**Regression analyses would have been used to determine this.**

Please list any significant constructs that the specified area of EF predicts for this measure/subtest (separate by comma):

Examples may include: adaptive skills, behavior problems, cognitive/intelligence, academic achievement

**Regression analyses would have been used to determine this.**
Please list any significant constructs that are correlated with the specified area of EF (separate by comma). Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement. (If not applicable, put “NA”). Put p-value and r in parentheses next to the construct. For example: adaptive skills (p = .002; r = .85).

**Correlation analyses would have been used to determine this.

Was another Assessment/Subtest used to analyze executive functioning?
- [ ] Yes
- [ ] No

### Measure 10

What type of assessment is this measure?
- [ ] Direct
- [ ] Indirect

Direct (requires a clinician to administer the test to an individual)
Indirect (the individual can do it independently - e.g., rating scale, questionnaire)
<table>
<thead>
<tr>
<th>What wide-range assessment was used (e.g., WISC, NEPSY-2, D2EFS)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Behavior Rating Inventory of Executive Function (BRIEF)</td>
</tr>
<tr>
<td>• Behavior Rating Inventory of Executive Function, 2nd Edition (BRIEF-2)</td>
</tr>
<tr>
<td>• Behavior Assessment System for Children (BASC)</td>
</tr>
<tr>
<td>• Behavior Assessment System for Children, 2nd Edition (BASC-2)</td>
</tr>
<tr>
<td>• Behavior Assessment System for Children, 3rd Edition (BASC-3)</td>
</tr>
<tr>
<td>• Conners 3rd Behavior Checklist (CBCL)</td>
</tr>
<tr>
<td>• Conners Rating Scales (CRS)</td>
</tr>
<tr>
<td>• Conners Rating Scale, Revised (CRS-R)</td>
</tr>
<tr>
<td>• Conners Rating Scales, 2nd Edition (Conners 2)</td>
</tr>
<tr>
<td>• Conners Rating Scales, 3rd Edition (Conners 3)</td>
</tr>
<tr>
<td>• Conners Performance Test (CPT)</td>
</tr>
<tr>
<td>• Conners Performance Test, 2nd Edition (CPT-2)</td>
</tr>
<tr>
<td>• Conners Performance Test, 3rd Edition (CPT-3)</td>
</tr>
<tr>
<td>• Delis-Kaplan Executive Function System (D-KEFS)</td>
</tr>
<tr>
<td>• A Developmental Neuropsychological Assessment (NEPSY)</td>
</tr>
<tr>
<td>• A Developmental Neuropsychological Assessment, 2nd Edition (NEPSY-II)</td>
</tr>
<tr>
<td>• Test of Everyday Attention for Children (TEA-CH)</td>
</tr>
<tr>
<td>• Wechsler Intelligence Scale for Children, 3rd Edition (WISC-III)</td>
</tr>
<tr>
<td>• Wechsler Intelligence Scale for Children, 4th Edition (WISC-IV)</td>
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<tr>
<td>• Wechsler Intelligence Scale for Children, 5th Edition (WISC-V)</td>
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<tr>
<td>• Wechsler Preschool and Primary Scale of Intelligence, 2nd Edition (WPPSI-II)</td>
</tr>
<tr>
<td>• Wechsler Preschool and Primary Scale of Intelligence, 3rd Edition (WPPSI-III)</td>
</tr>
<tr>
<td>• Wechsler Preschool and Primary Scale of Intelligence, 4th Edition (WPPSI-IV)</td>
</tr>
<tr>
<td>• Wechsler Abbreviated Scale of Intelligence (WASI)</td>
</tr>
<tr>
<td>• Wechsler Abbreviated Scale of Intelligence (WASI-II)</td>
</tr>
<tr>
<td>• Other</td>
</tr>
<tr>
<td>• Not applicable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What Subtest/Composite/Index was analyzed (from the wide-range assessment)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>(If not applicable, put &quot;NA&quot;)</td>
</tr>
</tbody>
</table>

*If more than one subtest/composite/index was used from the same wide-range assessment, complete a set of questions for each one.
<table>
<thead>
<tr>
<th>What traditional executive functioning assessment was used (e.g., Wisconsin Card Sorting Test)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Bricken Spatial Anticipation Test</td>
</tr>
<tr>
<td>□ Clock Drawing Test</td>
</tr>
<tr>
<td>□ Design Fluency Test</td>
</tr>
<tr>
<td>□ Go/NoGo Task</td>
</tr>
<tr>
<td>□ Greenwich Test</td>
</tr>
<tr>
<td>□ Hayling Sentence Completion Test</td>
</tr>
<tr>
<td>□ Hotel Test</td>
</tr>
<tr>
<td>□ Iowa Gambling Task</td>
</tr>
<tr>
<td>□ Letter-Number Span Test</td>
</tr>
<tr>
<td>□ Multiple Errands Test</td>
</tr>
<tr>
<td>□ N-back</td>
</tr>
<tr>
<td>□ Reading Span Test</td>
</tr>
<tr>
<td>□ Six Elements Test</td>
</tr>
<tr>
<td>□ Snaap Test</td>
</tr>
<tr>
<td>□ Sustained Attention to Response Task</td>
</tr>
<tr>
<td>□ Tinkertoy Test</td>
</tr>
<tr>
<td>□ Trail Making Test</td>
</tr>
<tr>
<td>□ Use of Objects and Alternate Uses Test</td>
</tr>
<tr>
<td>□ Verbal Fluency Test</td>
</tr>
<tr>
<td>□ Visuospatial Search Task</td>
</tr>
<tr>
<td>□ Wisconsin Card Sorting Test</td>
</tr>
<tr>
<td>□ Other</td>
</tr>
<tr>
<td>□ Not Applicable</td>
</tr>
</tbody>
</table>

Other

<table>
<thead>
<tr>
<th>What Subtest was analyzed from the traditional assessment?</th>
</tr>
</thead>
<tbody>
<tr>
<td>(for example, commissions from theorners performance test would be a &quot;subtest&quot;)</td>
</tr>
<tr>
<td>(If not applicable, put &quot;NA&quot;)</td>
</tr>
</tbody>
</table>

**If more than one subtest was used from the same wide-range assessment, complete a set of questions for each one**

<table>
<thead>
<tr>
<th>If a rating scale was used, who was the respondent?</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Parent/Caregiver</td>
</tr>
<tr>
<td>□ Teacher</td>
</tr>
<tr>
<td>□ Self Report</td>
</tr>
<tr>
<td>□ Not Applicable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What area of executive functioning did the measure analyze?</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Inhibition</td>
</tr>
<tr>
<td>□ Planning/Decision Making/Organizing</td>
</tr>
<tr>
<td>□ Emotion Regulation/Emotional Control</td>
</tr>
<tr>
<td>□ Cognitive Flexibility/Shift/Seating</td>
</tr>
<tr>
<td>□ Self Monitoring</td>
</tr>
<tr>
<td>□ Impeding</td>
</tr>
<tr>
<td>□ Working Memory</td>
</tr>
<tr>
<td>□ Task Monitoring</td>
</tr>
<tr>
<td>□ Organization of Materials</td>
</tr>
<tr>
<td>□ Attention</td>
</tr>
<tr>
<td>□ Meta-Cognition/Cognition Regulation</td>
</tr>
<tr>
<td>□ Behavior Regulation</td>
</tr>
<tr>
<td>□ Overall/Global Executive Functioning</td>
</tr>
<tr>
<td>□ [Other]</td>
</tr>
<tr>
<td>Question</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Which standardized score was reported?                                  | ○ Standard Score  
○ Scaled Score  
○ T-score  
○ Z-score  
○ Other  
○ A standardized score was not reported                                  |
<p>| What is the score for the ASD group?                                    | (If not applicable, put &quot;999&quot;)                                           |
| What is the standard deviation?                                         | (If not applicable, put &quot;999&quot;)                                           |
| What is the percentile rank?                                            | (If not applicable, put &quot;999&quot;)                                           |
| What is the score for the ASD/ADHD group?                               | (If not applicable, put &quot;999&quot;)                                           |
| What is the standard deviation?                                         | (If not applicable, put &quot;999&quot;)                                           |
| What is the percentile rank?                                            | (If not applicable, put &quot;999&quot;)                                           |
| What is the score for the ADHD group?                                   | (If not applicable, put &quot;999&quot;)                                           |
| What is the standard deviation?                                         | (If not applicable, put &quot;999&quot;)                                           |
| What is the percentile rank?                                            | (If not applicable, put &quot;999&quot;)                                           |</p>
<table>
<thead>
<tr>
<th>Question</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the score for the ID group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>What is the score for the ASD/ADHD/ID group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>What is the score for the [group_other] group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>What is the score for the [group_other_2] group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>What is the score for the typically developing group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
</tbody>
</table>
What is the percentile rank?

The following questions ask about the mean/standard deviations for each group.
What variable is the mean/SD about (e.g., errors)?
What is the mean for the ASD group?
What is the standard deviation?
What is the mean for the ASD/ID group?
What is the standard deviation?
What is the mean for the ASD/ADHD group?
What is the standard deviation?
What is the mean for the ADHD group?
What is the standard deviation?
What is the mean for the ID group?
What is the standard deviation?
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the mean for the [group_other] group?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the mean for the [group_other_2] group?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the mean for the typically developing group?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put “999”)</td>
</tr>
<tr>
<td>Please specify which groups were significantly different</td>
<td>(Use this format: “ASD &lt; ASD/ID (p-value), (effect size); ASD &gt; TD (p-value), (effect size)...” If not applicable, put “999”)</td>
</tr>
<tr>
<td>Please list any significant predictors of the area of EF specified for this measure/subtest (separate with commas)</td>
<td>(If not applicable, put “NA”. Put p-value in parentheses next to the construct. For example: adaptive skills (p = .002))</td>
</tr>
<tr>
<td>Examples may include adaptive skills, behavior problems, cognitive intelligence, academic achievement</td>
<td><strong>Regression analyses would have been used to determine this</strong></td>
</tr>
<tr>
<td>Please list any significant constructs that the specified area of EF predicts for this measure/subtest (separate by comma)</td>
<td>(If not applicable, put “NA”. Put p-value in parentheses next to the construct. For example: adaptive skills (p = .002))</td>
</tr>
<tr>
<td>Examples may include adaptive skills, behavior problems, cognitive intelligence, academic achievement</td>
<td><strong>Regression analyses would have been used to determine this</strong></td>
</tr>
</tbody>
</table>
Please list any significant constructs that are correlated with the specified area of EF (separate by comma).

Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement

**Correlation analyses would have been used to determine this**

Was another Assessment/Subtest used to analyze executive functioning?

- [ ] Yes
- [x] No

**Measure 11**

What type of assessment is this measure?

- [ ] Direct
- [ ] Indirect

Direct (requires a clinician to administer the test to an individual)
Indirect (the individual can do it independently - e.g., rating scale, questionnaire)
What wide-range assessment was used (e.g., WISC, NEPSY-II, D2KFS)?

- Behavior Rating Inventory of Executive Function (BRIEF)
- Behavior Rating Inventory of Executive Function, 2nd Edition (BRIEF-2)
- Behavior Assessment System for Children (BASC)
- Behavior Assessment System for Children, 2nd Edition (BASC-2)
- Behavior Assessment System for Children, 3rd Edition (BASC-3)
- Child Behavior Checklist (CBCL)
- Conners Rating Scales (CRS)
- Conners Rating Scales, Revised (CRS-R)
- Conners Rating Scales, 2nd Edition (Conners 2)
- Conners Rating Scales, 3rd Edition (Conners 3)
- Conners Performance Test (CPT)
- Conners Performance Test, 2nd Edition (CPT-2)
- Conners Performance Test, 3rd Edition (CPT-3)
- Delis-Kaplan Executive Function System (D2KFS)
- A Developmental Neuropsychological Assessment (NEPSY)
- A Developmental Neuropsychological Assessment, 2nd Edition (NEPSY-II)
- Test of Everyday Attention for Children (TEA-Ch)
- Wechsler Intelligence Scale for Children, 3rd Edition (WISC-III)
- Wechsler Intelligence Scale for Children, 4th Edition (WISC-IV)
- Wechsler Intelligence Scale for Children, 5th Edition (WISC-V)
- Wechsler Preschool and Primary Scale of Intelligence, 2nd Edition (WPPSI-II)
- Wechsler Preschool and Primary Scale of Intelligence, 3rd Edition (WPPSI-III)
- Wechsler Preschool and Primary Scale of Intelligence, 4th Edition (WPPSI-IV)
- Wechsler Abbreviated Scale of Intelligence (WASI)
- Other
- Not applicable

What Subtest/Composite/Index was analyzed (from the wide-range assessment)?

* If more than one subtest/composite/index was used from the same wide-range assessment, complete a set of questions for each one.
<table>
<thead>
<tr>
<th>What traditional executive functioning assessment was used (e.g., Wisconsin Card Sorting Test)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Brixton Spatial Anticipation Test</td>
</tr>
<tr>
<td>☐ Clock Drawing Test</td>
</tr>
<tr>
<td>☐ Design Fluency Test</td>
</tr>
<tr>
<td>☐ Go/NoGo Task</td>
</tr>
<tr>
<td>☐ Greenwich Test</td>
</tr>
<tr>
<td>☐ Rey Osterrieth Complex Figure Test - Copy</td>
</tr>
<tr>
<td>☐ HOT FIGT</td>
</tr>
<tr>
<td>☐ Iowa Gambling Task</td>
</tr>
<tr>
<td>☐ Letter Number Span Test</td>
</tr>
<tr>
<td>☐ Multiple Errors Test</td>
</tr>
<tr>
<td>☐ N-back</td>
</tr>
<tr>
<td>☐ Reading Span Test</td>
</tr>
<tr>
<td>☐ Six Elements Test</td>
</tr>
<tr>
<td>☐ Stroop Test</td>
</tr>
<tr>
<td>☐ Sustained Attention to Response Task</td>
</tr>
<tr>
<td>☐ Tapping Motor Test</td>
</tr>
<tr>
<td>☐ Trail Making Test</td>
</tr>
<tr>
<td>☐ Use of Objects and Alternate Uses Test</td>
</tr>
<tr>
<td>☐ Verbal Fluency Test</td>
</tr>
<tr>
<td>☐ Visual Spatial Span Task</td>
</tr>
<tr>
<td>☐ Visuospatial Working Memory Test</td>
</tr>
<tr>
<td>☐ Wisconsin Card Sorting Test</td>
</tr>
<tr>
<td>☐ Other</td>
</tr>
<tr>
<td>☐ Not Applicable</td>
</tr>
</tbody>
</table>

**Other**

What Subtest was analyzed from the traditional assessment?

*(if more than one subtest was used from the same wide-range assessment, complete a set of questions for each one)*

If a rating scale was used, who was the respondent?

<table>
<thead>
<tr>
<th>If a rating scale was used, who was the respondent?</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Parent/Caregiver</td>
</tr>
<tr>
<td>☐ Teacher</td>
</tr>
<tr>
<td>☐ Self Report</td>
</tr>
<tr>
<td>☐ Not Applicable</td>
</tr>
</tbody>
</table>

What area of executive functioning did the measure analyze?

<table>
<thead>
<tr>
<th>What area of executive functioning did the measure analyze?</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Inhibition</td>
</tr>
<tr>
<td>☐ Planning/Decision Making/Organizing</td>
</tr>
<tr>
<td>☐ Emotion Regulation/Emotional Control</td>
</tr>
<tr>
<td>☐ Cognitive Flexibility/Shifting/Switching</td>
</tr>
<tr>
<td>☐ Self Monitoring</td>
</tr>
<tr>
<td>☐ Initiating</td>
</tr>
<tr>
<td>☐ Working Memory</td>
</tr>
<tr>
<td>☐ Task Monitoring</td>
</tr>
<tr>
<td>☐ Organization of Materials</td>
</tr>
<tr>
<td>☐ Attention</td>
</tr>
<tr>
<td>☐ Meta-cognition/Cognition Regulation</td>
</tr>
<tr>
<td>☐ Behavior Regulation</td>
</tr>
<tr>
<td>☐ Overall/Global Executive Functioning</td>
</tr>
<tr>
<td>☐ [if other]</td>
</tr>
<tr>
<td>Question</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Which standardized score was reported?</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>What is the score for the ASD group?</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
</tr>
<tr>
<td>What is the percentile rank?</td>
</tr>
<tr>
<td>What is the score for the ASD/ADHD group?</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
</tr>
<tr>
<td>What is the percentile rank?</td>
</tr>
<tr>
<td>What is the score for the ADHD group?</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
</tr>
<tr>
<td>What is the percentile rank?</td>
</tr>
</tbody>
</table>
What is the score for the ID group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the percentile rank? (If not applicable, put "999")

What is the score for the ASD/ADHD/ID group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the percentile rank? (If not applicable, put "999")

What is the score for the [group_other] group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the percentile rank? (If not applicable, put "999")

What is the score for the [group_other_2] group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the percentile rank? (If not applicable, put "999")

What is the score for the typically developing group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")
<table>
<thead>
<tr>
<th>Question</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the percentile rank?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>The following questions ask about the mean/standard deviations for each group.</td>
<td></td>
</tr>
<tr>
<td>What variable is the mean/SD about (e.g., errors)?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the ASD group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the ASD/ADHD group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the ADHD group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the ID group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the mean for the ASD/ADHD/ID group?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>(If not applicable, put &quot;999&quot;)</td>
</tr>
</tbody>
</table>
What is the mean for the [group_other] group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the mean for the [group_other_2] group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

What is the mean for the typically developing group? (If not applicable, put "999")

What is the standard deviation? (If not applicable, put "999")

Please specify which groups were significantly different

(Use the format: "ASD < TD (p-value), effect size) ASD > TD (p-value), (effect size)"
If not applicable, put "999")

Please list any significant predictors of the area of EF specified for this measuresubtest (separate with commas)

Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement

*Regression analyses would have been used to determine this

Please list any significant constructs that the specified area of EF predicts for this measuresubtest (separate by comma)

Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement

*Regression analyses would have been used to determine this
Confidential

Please list any significant constructs that are correlated with the specified area of EF (separate by comma).

Examples may include: adaptive skills, behavior problems, cognitive/intelligence, academic achievement.

(*Correlation analyses would have been used to determine this. If not applicable, put "NA". Put p-value and r in parentheses next to the construct. For example: adaptive skills (p = .002; r = .85)).

Was another Assessment/Subtest used to analyze executive functioning?

- Yes
- No

**Measure 12**

What type of assessment is this measure?

- Direct
- Indirect

Direct (requires a clinician to administer the test to an individual).
Indirect (the individual can do it independently - e.g., rating scale, questionnaire).
<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>What wide-range assessment was used (e.g., WISC, NEPSY-2, DKEFS)?</td>
<td>- Behavior Rating Inventory of Executive Function (BRIEF)</td>
</tr>
<tr>
<td></td>
<td>- Behavior Rating Inventory of Executive Function, 2nd Edition (BRIEF-2)</td>
</tr>
<tr>
<td></td>
<td>- Behavior Assessment System for Children (BASC)</td>
</tr>
<tr>
<td></td>
<td>- Behavior Assessment System for Children, 2nd Edition (BASC-2)</td>
</tr>
<tr>
<td></td>
<td>- Behavior Assessment System for Children, 3rd Edition (BASC-3)</td>
</tr>
<tr>
<td></td>
<td>- Conners Rating Scale (CRS)</td>
</tr>
<tr>
<td></td>
<td>- Conners Rating Scale, Revised (CRS-R)</td>
</tr>
<tr>
<td></td>
<td>- Conners Rating Scales, 2nd Edition (Conners 2)</td>
</tr>
<tr>
<td></td>
<td>- Conners Rating Scales, 3rd Edition (Conners 3)</td>
</tr>
<tr>
<td></td>
<td>- Conners Performance Test (CPT)</td>
</tr>
<tr>
<td></td>
<td>- Conners Performance Test, 2nd Edition (CPT-2)</td>
</tr>
<tr>
<td></td>
<td>- Conners Performance Test, 3rd Edition (CPT-3)</td>
</tr>
<tr>
<td></td>
<td>- Delis-Kaplan Executive Function System (D-KEFS)</td>
</tr>
<tr>
<td></td>
<td>- A Developmental Neuropsychological Assessment (NEPSY-II)</td>
</tr>
<tr>
<td></td>
<td>- Test of Everyday Attention for Children (TEA-CH)</td>
</tr>
<tr>
<td></td>
<td>- Wechsler Intelligence Scale for Children, 3rd Edition (WISC-III)</td>
</tr>
<tr>
<td></td>
<td>- Wechsler Intelligence Scale for Children, 4th Edition (WISC-IV)</td>
</tr>
<tr>
<td></td>
<td>- Wechsler Intelligence Scale for Children, 5th Edition (WISC-V)</td>
</tr>
<tr>
<td></td>
<td>- Wechsler Preschool and Primary, Scale of Intelligence, 2nd Edition (WPPSI-II)</td>
</tr>
<tr>
<td></td>
<td>- Wechsler Preschool and Primary, Scale of Intelligence, 3rd Edition (WPPSI-III)</td>
</tr>
<tr>
<td></td>
<td>- Wechsler Preschool and Primary, Scale of Intelligence, 4th Edition (WPPSI-IV)</td>
</tr>
<tr>
<td></td>
<td>- Wechsler Abbreviated Scale of Intelligence (WASI)</td>
</tr>
<tr>
<td></td>
<td>- Other</td>
</tr>
<tr>
<td></td>
<td>- Not applicable</td>
</tr>
<tr>
<td>What Subtest/Composite/index was analyzed (from the wide-range assessment)?</td>
<td>(If not applicable, put &quot;NA&quot;)</td>
</tr>
<tr>
<td><em>If more than one subtest/composite/index was used from the same wide-range assessment, complete a set of questions for each one</em></td>
<td></td>
</tr>
</tbody>
</table>
What traditional executive functioning assessment was used (e.g., Wisconsin Card Sorting Test)?

- Britton Spatial Anticipation Test
- Clock Drawing Test
- Design Fluency Test
- Go/NoGo Task
- Greenwich Test
- Hayling Sentence Completion Test
- Hotel Test
- Iowa Gambling Task
- Letter-Number Span Test
- Multiple Errands Test
- N-back
- Reading Span Test
- Six Elements Test
- Sstroop Test
- Sustained Attention to Response Task
- Tinkertoy Test
- Trail Making Test
- Use of Objects and Alternate Uses Test
- Verbal Fluency Test
- Visual-Spatial Span Task
- Visual-Spatial Working Memory Test
- Wisconsin Card Sorting Test
- Other
- Not Applicable

Other

What Subtest was analyzed from the traditional assessment? (If not applicable, put "NA")

(for example, commissions from the corners performance test would be a "subtest")

*If more than one subtest was used from the same wide-range assessment, complete a set of questions for each one

If a rating scale was used, who was the respondent?

- Parent/Caregiver
- Teacher
- Self-Report
- Not Applicable

What area of executive functioning did the measure analyze?

- Inhibition
- Planning/Decision Making/Organizing
- Emotion Regulation/Emotional Control
- Cognitive Flexibility/Shifting/Switching
- Self Monitoring
- Initiating
- Working Memory
- Task Monitoring
- Organization of Materials
- Attention
- Meta-cognition/Cognition Regulation
- Behavior Regulation
- Overall/Global Executive Functioning
- [ef_other]
Which standardized score was reported?  
- [ ] Standard Score  
- [ ] Scaled Score  
- [ ] T-score  
- [ ] Z-score  
- [ ] Other  
- [ ] A standardized score was not reported

Other

What is the score for the ASD group?  
(If not applicable, put "999")

What is the standard deviation?  
(If not applicable, put "999")

What is the percentile rank?  
(If not applicable, put "999")

What is the score for the ASD/ADHD group?  
(If not applicable, put "999")

What is the standard deviation?  
(If not applicable, put "999")

What is the percentile rank?  
(If not applicable, put "999")

What is the score for the ADHD group?  
(If not applicable, put "999")

What is the standard deviation?  
(If not applicable, put "999")

What is the percentile rank?  
(If not applicable, put "999")
What is the percentile rank?

The following questions ask about the mean/standard deviations for each group.

What variable is the mean/SD about (e.g., errors)?

What is the mean for the ASD group?

What is the standard deviation?

What is the mean for the ASD/ADHD group?

What is the standard deviation?

What is the mean for the ADHD group?

What is the standard deviation?

What is the mean for the ID group?

What is the standard deviation?

What is the mean for the ASD/ADHD/ID group?

What is the standard deviation?
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the mean for the typically developing group?</td>
<td>If not applicable, put &quot;9999&quot;</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>If not applicable, put &quot;9999&quot;</td>
</tr>
<tr>
<td>What is the mean for the [group_other] group?</td>
<td>If not applicable, put &quot;9999&quot;</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>If not applicable, put &quot;9999&quot;</td>
</tr>
<tr>
<td>What is the mean for the [group_other_2] group?</td>
<td>If not applicable, put &quot;9999&quot;</td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td>If not applicable, put &quot;9999&quot;</td>
</tr>
<tr>
<td>Please specify which groups were significantly different</td>
<td>(Use this format: &quot;ASD &lt; ASD/ID (p-value), (effect size); ASD &gt; TD (p-value), (effect size)...&quot;) If not applicable, put &quot;9999&quot;</td>
</tr>
<tr>
<td>Please list any significant predictors of the area of EF specified for this measure/subtest (separate with commas)</td>
<td>If not applicable, put &quot;NA&quot;. Put p-value in parentheses next to the construct. For example: adaptive skills (p = .002)</td>
</tr>
</tbody>
</table>

Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement

*Regression analyses would have been used to determine this

Please list any significant constructs that the specified area of EF predicts for this measure/subtest (separate by commas)

Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement

*Regression analyses would have been used to determine this

3/24/2023 9:56am projectredcap.org REDCap
Please list any significant constructs that are correlated with the specified area of EF (separate by comma).

Examples may include: adaptive skills, behavior problems, cognitive/Intelligence, academic achievement

**Correlation analyses would have been used to determine this.**

(if not applicable, put "NA". Put p-value and r in parentheses next to the construct. For example: adaptive skills (p = .002, r = .85))

Was another Assessment/Subtest used to analyze executive functioning?

- Yes
- No

### Measure 13

What type of assessment is this measure?

- Direct
- Indirect

Direct (requires a clinician to administer the test to an individual)
Indirect (the individual can do it independently - e.g., rating scale, questionnaire)
What wide-range assessment was used (e.g., WISC, NEPSY-2, DKEFS)?

- Behavior Rating Inventory of Executive Function (BRIEF)
- Behavior Rating Inventory of Executive Function, 2nd Edition (BRIEF-2)
- Behavior Assessment System for Children (BASC)
- Behavior Assessment System for Children, 2nd Edition (BASC-2)
- Behavior Assessment System for Children, 3rd Edition (BASC-3)
- Child Behavior Checklist (CBCL)
- Conners Rating Scales (CRS)
- Conners Rating Scale, Revised (CRS-R)
- Conners Rating Scales, 2nd Edition (Conners 2)
- Conners Rating Scales, 3rd Edition (Conners 3)
- Conners Performance Test (CPT)
- Conners Performance Test, 2nd Edition (CPT-2)
- Conners Performance Test, 3rd Edition (CPT-3)
- Delo-Kaplan Executive Function System (D-KEFS)
- A Developmental Neuropsychological Assessment (NEPSY)
- A Developmental Neuropsychological Assessment, 2nd Edition (NEPSY-II)
- Test of Everyday Attention for Children (TEA-CH)
- Wechsler Intelligence Scale for Children, 3rd Edition (WISC-III)
- Wechsler Intelligence Scale for Children, 4th Edition (WISC-IV)
- Wechsler Intelligence Scale for Children, 5th Edition (WISC-V)
- Wechsler Preschool and Primary Scale of Intelligence, 2nd Edition (WPPSI-II)
- Wechsler Preschool and Primary Scale of Intelligence, 3rd Edition (WPPSI-III)
- Wechsler Preschool and Primary Scale of Intelligence, 4th Edition (WPPSI-IV)
- Wechsler Abbreviated Scale of Intelligence (WASI)
- Wechsler Abbreviated Scale of Intelligence (WASI-II)
- Other
- Not applicable

Other

What Subtest/Composite/Index was analyzed (from the wide-range assessment)?

(If not applicable, put "N/A")

*If more than one subtest/composite/index was used from the same wide-range assessment, complete a set of questions for each one...
What traditional executive functioning assessment was used (e.g., Wisconsin Card Sorting Test)?

- Bracken Spatial Anticipation Test
- Clock Drawing Test
- Design Fluency Test
- Go/NoGo Task
- Greifswald Test
- Hayling Sentence Completion Test
- Hotel Test
- Iowa Gambling Task
- Letter Number Span Test
- Multiple Errors Test
- N-back
- Reading Span Test
- Six Elements Test
- Stroop Test
- Sustained Attention to Response Task
- Trinkov Test
- Trail Making Test
- Use of Objects and Alternate Uses Test
- Verbal Fluency Test
- Visual-Spatial Span Task
- Visual-Spatial Working Memory Test
- Wisconsin Card Sorting Test
- Other
- Not Applicable

Other

What subtest was analyzed from the traditional assessment?
(for example, commissions from the corners performance test would be a subtask."

If more than one subtest was used from the same wide-range assessment, complete a set of questions for each one.

If a rating scale was used, who was the respondent?

- Parent/Caregiver
- Teacher
- Self-Report
- Not Applicable

What area of executive functioning did the measure analyze?

- Inhibition
- Planning/Decision Making/Organizing
- Emotion Regulation/Emotional Control
- Cognitive Flexibility/Shifting/Switching
- Self Monitoring
- Initiating
- Working Memory
- Task Monitoring
- Organization of Materials
- Attention
- Metacognition/Cognition Regulation
- Behavior Regulation
- Overall/Global Executive Functioning
- Other
Which standardized score was reported?
- □ Standard Score
- □ Scaled Score
- □ T-score
- □ Z-score
- □ Other
- □ A standardized score was not reported

Other

What is the score for the ASD group?
[If not applicable, put "999"]

What is the standard deviation?
[If not applicable, put "999"]

What is the percentile rank?
[If not applicable, put "999"]

What is the score for the ASD/ADHD group?
[If not applicable, put "999"]

What is the standard deviation?
[If not applicable, put "999"]

What is the percentile rank?
[If not applicable, put "999"]

What is the score for the ADHD group?
[If not applicable, put "999"]

What is the standard deviation?
[If not applicable, put "999"]

What is the percentile rank?
[If not applicable, put "999"]
What is the score for the ID group? [If not applicable, put "999"]

What is the standard deviation? [If not applicable, put "999"]

What is the percentile rank? [If not applicable, put "999"]

What is the score for the AS 받아 [group_other] group? [If not applicable, put "999"]

What is the standard deviation? [If not applicable, put "999"]

What is the percentile rank? [If not applicable, put "999"]

What is the score for the typically developing group? [If not applicable, put "999"]

What is the standard deviation? [If not applicable, put "999"]

What is the percentile rank? [If not applicable, put "999"]

What is the score for the (group_other) group? [If not applicable, put "999"]

What is the standard deviation? [If not applicable, put "999"]

What is the percentile rank? [If not applicable, put "999"]

What is the score for the (group_other_2) group? [If not applicable, put "999"]

What is the standard deviation? [If not applicable, put "999"]
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the percentile rank?</td>
<td></td>
</tr>
<tr>
<td>The following questions ask about the mean/standard deviations for each group.</td>
<td></td>
</tr>
<tr>
<td>What variable is the mean/SD about (e.g., errors)?</td>
<td></td>
</tr>
<tr>
<td>What is the mean for the ASD group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the mean for the ASD/ID group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the mean for the ASD/ADHD group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the mean for the ADHD group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the mean for the ID group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
<tr>
<td>What is the mean for the ASD/ADHD/ID group?</td>
<td></td>
</tr>
<tr>
<td>What is the standard deviation?</td>
<td></td>
</tr>
</tbody>
</table>
What is the mean for the typically developing group?  (If not applicable, put "999")

What is the standard deviation?  (If not applicable, put "999")

What is the mean for the [group_either] group?  (If not applicable, put "999")

What is the standard deviation?  (If not applicable, put "999")

What is the mean for the [group_other_2] group?  (If not applicable, put "999")

What is the standard deviation?  (If not applicable, put "999")

Please specify which groups were significantly different  

(Use this format: "ASD < ASD/ID (p-value), (effect size); ASD > TD (p-value), (effect size)..."); If not applicable, put "999")

Please list any significant predictors of the area of EF specified for this measure/subtest (separate with commas)

Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement

*Regression analyses would have been used to determine this

Please list any significant constructs that the specified area of EF predicts for this measure/subtest (separate by commas)

Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement

*Regression analyses would have been used to determine this
Please list any significant constructs that are correlated with the specified area of EF (separate by commas). Examples may include: adaptive skills, behavior problems, cognitive intelligence, academic achievement (if not applicable, put "NA"). Put p-value and r in parentheses next to the construct. For example: adaptive skills (p = .002; r = .85)).

**Correlation analyses would have been used to determine this.**

Notes/Comments/Questions
APPENDIX C

DEMOGRAPHICS SURVEY
Demographics Survey

Family Demographics

Please complete the survey below.

Thank you!

Today’s Date

Marital Status of Parents/Caregivers

☐ Married
☐ Never married or single
☐ Divorced or separated
☐ Widowed
☐ Domestic partnership
☐ Other

If Other, please describe:

Which best describes your gross annual household income?

☐ 0-$19,925
☐ $19,926-$38,700
☐ $38,701-$62,500
☐ $62,501-$157,500
☐ $157,501-$200,000
☐ $200,001-$500,000
☐ $500,001 or more

Parent/Caregiver #1

Relationship to child

☐ Mother
☐ Father
☐ Other

If Other, please describe:

How do you currently describe your gender identity?

☐ Female
☐ Male
☐ Other
☐ Prefer not to respond

If Other, please describe:

Which best describes your race/ethnicity?

☐ American Indian or Alaska Native
☐ Asian
☐ Black or African American
☐ Latino and/or Hispanic
☐ White
☐ Other

If Other, please describe:
### Confidential

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which best describes your highest education?</td>
<td>- Less than High School&lt;br&gt; - High School or GED&lt;br&gt; - Some College&lt;br&gt; - Associate's Degree&lt;br&gt; - Bachelor's Degree&lt;br&gt; - Professional Degree&lt;br&gt; - Doctorate</td>
</tr>
<tr>
<td>Which best describes your current employment status?</td>
<td>- Employed full time (40 or more hours per week)&lt;br&gt; - Employed part time (less than 35 hours per week)&lt;br&gt; - Unemployed and currently looking for work&lt;br&gt; - Retired&lt;br&gt; - Homemaker&lt;br&gt; - Unable to work</td>
</tr>
<tr>
<td><strong>Parent/Caregiver #2</strong></td>
<td></td>
</tr>
<tr>
<td>Relationship to child</td>
<td>- Mother&lt;br&gt; - Father&lt;br&gt; - NA&lt;br&gt; - Other</td>
</tr>
<tr>
<td>Which best describes parent/caregiver 2's gender identity?</td>
<td>- Female&lt;br&gt; - Male&lt;br&gt; - Other&lt;br&gt; - Prefer not to respond</td>
</tr>
<tr>
<td><strong>If Other, please describe:</strong></td>
<td></td>
</tr>
<tr>
<td>Which best describes Parent/Caregiver 2's race/ethnicity?</td>
<td>- American Indian or Alaska Native&lt;br&gt; - Asian&lt;br&gt; - Black or African American&lt;br&gt; - Latino and/or Hispanic&lt;br&gt; - White&lt;br&gt; - Other</td>
</tr>
<tr>
<td><strong>If Other, please describe:</strong></td>
<td></td>
</tr>
<tr>
<td>Which best describes Parent/Caregiver 2's education?</td>
<td>- Less than High School&lt;br&gt; - High School or GED&lt;br&gt; - Some College&lt;br&gt; - Associate's Degree&lt;br&gt; - Bachelor's Degree&lt;br&gt; - Professional Degree&lt;br&gt; - Doctorate</td>
</tr>
<tr>
<td>Which best describes Parent/Caregiver 2's employment?</td>
<td>- Employed full time (40 or more hours per week)&lt;br&gt; - Employed part time (less than 35 hours per week)&lt;br&gt; - Unemployed and currently looking for work&lt;br&gt; - Retired&lt;br&gt; - Homemaker&lt;br&gt; - Unable to work</td>
</tr>
</tbody>
</table>
### Do either parents/caregivers have an immediate family history of learning or educational problems?

<table>
<thead>
<tr>
<th></th>
<th>Reading difficulties</th>
<th>Written language difficulties</th>
<th>Speech/language problems</th>
<th>Vision difficulties</th>
<th>Hearing difficulties</th>
<th>Special education services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caregiver #1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caregiver #2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children (other than the child participating in this study)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please indicate speech/language problems for Parent/Caregiver 1:

- Receptive language
- Expressive language
- Speech sound production problems
- Stuttering
- Voice

Please indicate speech/language problems for Parent/Caregiver 2:

- Receptive language
- Expressive language
- Speech sound production problems
- Stuttering
- Voice

Please indicate speech/language problems for the child(ren):

- Receptive language
- Expressive language
- Speech sound production problems
- Stuttering
- Voice

### Do either parents/caregivers have an immediate family history of mental health problems?

<table>
<thead>
<tr>
<th></th>
<th>Autism Spectrum Disorder</th>
<th>Attention-Deficit/Hyperactivity Disorder</th>
<th>Intellectual Disability</th>
<th>Specific Learning Disability</th>
<th>Anxiety or Depression</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caregiver #1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caregiver #2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children (other than the child participating in this study)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If Other, please describe:

---

Which best describes your child's race/ethnicity?

- American Indian or Alaska Native
- Asian
- Black or African American
- Latino and/or Hispanic
- White
- Other

If Other, please describe:

---
<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has your child ever participated in previous mental health or behavioral treatment (e.g., outpatient counseling, speech-language therapy, etc.)?</td>
<td>○ Yes ○ No</td>
</tr>
<tr>
<td>If Yes, please describe:</td>
<td></td>
</tr>
<tr>
<td>When did your child first say single words?</td>
<td>○ Approximately 12 months ○ Approximately 18 months ○ 18-24 months ○ 24-30 months ○ 30-36 months ○ Over 36 months of age</td>
</tr>
<tr>
<td>When did your child first use 2-3 word sentences?</td>
<td>○ Approximately 24 months ○ Approximately 36 months ○ Approximately 48 months ○ Over 48 months</td>
</tr>
<tr>
<td>Did your child have a history of chronic ear infections?</td>
<td>○ Yes ○ No</td>
</tr>
<tr>
<td>Did your child ever require the placement of ear tubes?</td>
<td>○ Yes ○ No</td>
</tr>
<tr>
<td>Has your child ever received a psychological or psychoeducational evaluation?</td>
<td>○ Yes ○ No</td>
</tr>
<tr>
<td>Where did your child receive this evaluation?</td>
<td></td>
</tr>
<tr>
<td>Who was the clinician/practitioner who oversaw this evaluation?</td>
<td></td>
</tr>
<tr>
<td>If in an evaluation clinic, what diagnoses (if any) were made?</td>
<td>(If not applicable, put &quot;NA&quot;)</td>
</tr>
<tr>
<td>If in the school, what special education classification (if any) was made?</td>
<td>(If not applicable, put &quot;NA&quot;)</td>
</tr>
<tr>
<td>Has your child ever received a speech-language evaluation?</td>
<td>○ Yes ○ No</td>
</tr>
<tr>
<td>If Yes, please describe:</td>
<td></td>
</tr>
<tr>
<td>Has your child ever received a hearing evaluation?</td>
<td>○ Yes ○ No</td>
</tr>
<tr>
<td>If Yes, please describe:</td>
<td></td>
</tr>
<tr>
<td>Is your child currently taking any medication?</td>
<td>○ Yes ○ No</td>
</tr>
</tbody>
</table>
Confidential

Page 5

If Yes, what medication?

Did your child take their medication prior to today's visit?

- Yes
- No
- I don't know

What grade is your child in?

- Kindergarten
- 1 to 2
- 3 to 4
- 5 to 6
- 7 to 8
- 9 to 10
- 11 to 12

Do you have any concerns regarding your child's academic performance?

- Yes
- No

If Yes, please describe:

Has your child ever repeated a grade?

- Yes
- No

Is your child receiving special education services?

- Yes
- No

If Yes, please describe:

How did you hear about this study?

- Flyer
- Social media
- Child's school
- Contact from participation in a previous research study conducted by this team
- Other

If Other, please describe:

__________________________________________
APPENDIX D

PHONE SCREENER
Executive Functioning in Children with ASD and other NDDs
Phone Screener

Read the following to caregivers prior to starting screening: The current study involves one in-clinic visit. Prior to the in-clinic visit, we ask that you answer a few questions over the phone today to ensure that you and your child meet criteria to participate in the current study. This process should take approximately 5 to 10 minutes. If after we complete the phone screener today and you do not meet criteria, all information collected will immediately be shredded. If after we complete the phone screener and you meet criteria to participate in the current study, we will schedule your clinic visit. Do you have any questions?

Caregiver Name: __________________________________________

Phone Number: _________________________________________________

Email Address:_______________________________________________

Child Name: ____________________________________________________

Child Date of Birth: ______________________________________________

Child Grade: ____________________________

Does your child have Autism Spectrum Disorder (ASD)? ______________

If yes, when was your child diagnosed? ____________________________

If yes, who diagnosed your child? ____________________________

If yes, does your child have any co-occurring (formal) diagnoses/SPED classifications, such as intellectual disability, learning disorder, or ADHD?

____________________________________________________

If yes, what is the diagnosis?

____________________________________________________

If yes, when was your child diagnosed?

____________________________________________________

If yes, who diagnosed your child?
Does your child receive any special education services at school? ______________________

If yes, under what eligibility category? ______________________

Do you have concerns regarding your child’s academic performance? ______________________

If yes, please describe:

Do you have concerns regarding your child’s hearing? ______________________

If yes, please describe:

Do you have concerns regarding your child’s speech and/or language? ______________________

If yes, please describe:

Date phone screener completed: ________ Researcher who conducted phone screening: ______

Does participant meet initial criteria for study participation? ______________________

If yes, assigned study number: ______________________

If yes, initial/date entry into combined ASD studies tracking: ______________________
If yes, initial/date entry into EF ASD tracking database:___________________________
APPENDIX E

RESEARCH SESSION CHECKLIST
CV Session 1

<table>
<thead>
<tr>
<th>Step</th>
<th>Task</th>
<th>RA Initial</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Have caregiver(s) complete <strong>EF ASD consent &amp; child complete assent</strong>, give a copy to the caregiver(s)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>If caregiver(s) initial to have their contact information entered into our future study database, add their information:</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Have caregiver(s) complete the <strong>demographic form</strong> on the computer/ipad via Redcap</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Have caregiver(s) complete the <strong>BRIEF-2</strong> on the computer/ipad</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Have caregiver(s) complete the <strong>Conners 3P</strong> on the computer/ipad</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Have caregiver(s) complete the <strong>ASRS</strong> on the computer/ipad</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Administer the <strong>WASI-II</strong></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Give family <strong>$10 gift card for EF ASD</strong> and complete <strong>incentive log</strong> <strong>Make sure this the EF ASD cash box</strong></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Make sure the family has signed incentive log <strong>Write down gift card numbers in incentive log</strong></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Child chooses 1 toy from toy box</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Score rating forms (select the score option at the links above) and upload report form to Box for EF ASD</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Enter data in EF ASD Redcap data entry form within 48 hours</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Place all protocols and forms in the child’s file &amp; store</td>
<td></td>
</tr>
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APPENDIX F

STATISTICAL CODE AND R OUTPUT
Appendix F
Statistical Analysis

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<td>339</td>
</tr>
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<td>Fit Model</td>
<td>339</td>
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<td>Model A</td>
<td>340</td>
</tr>
<tr>
<td>Fit Model</td>
<td>340</td>
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<td>Parameter Estimates</td>
<td>340</td>
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<td>Effect Size</td>
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<td>Model B</td>
<td>342</td>
</tr>
<tr>
<td>Fit Model</td>
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<td>Parameter Estimates</td>
<td>342</td>
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<td>Effect Size</td>
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<td>345</td>
</tr>
</tbody>
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Preparation

Load Packages

```r
library(tidyverse)  # Loads several very helpful 'tidy' packages
library(furniture)  # Nice tables
library(psych)
library(lubridate)
library(ggpubr)
library(lme4)
library(lmerTest)
library(texreg)
library(performance)
library(mice)
library(naniar)
library(pander)
```

Load Data

```r
load("Dissertation_clean_data.RData")

dim(data_clean_main_all)

[1] 65 69
```
Wrangle Data

Wide Format

n = 65 kids

data_wide_raw <- data_clean_main_all %>%
dplyr::select(ID, sample,
    child_age_yrs,
    child_sex,
    covid_onset,
    starts_with("combined"),
    starts_with("BRIEF"),
    starts_with("brief"),
    starts_with("asrs"),
    starts_with("C3P"),
    starts_with("c3p")) %>%
dplyr::mutate(sample = factor(sample)) %>%
dplyr::mutate(covid_onset = factor(covid_onset)) %>%
dplyr::mutate(child_sex = child_sex %>%
   forcats::fct_recode(NULL = "Transgender",
    NULL = "Not Available"))

nrow(data_wide_raw)

[1] 65
Long Format

Long format (n = 65 kids x 3-Brief = 195 potential lines)
Level 2: Macro-units = participant * IV = ASRS, C3P, IQ
Level 1: Micro-units = observations * IV = domain of ExFun (Emot, Behav, Cog) * DV = subscore

Need: Long format, 1 line per domain of ExFun

  - BRIEF_bx_t The t-score for behavior regulation index (BRI)
  - BRIEF_emot_t The t-score for the emotion regulation index (ERI)
  - BRIEF_cog_t The t-score for the cognitive regulation index (CRI)

```r
data_long <- data_wide_raw %>%
  tidyr::pivot_longer(cols = c(BRIEF_bx_t, BRIEF_emot_t, BRIEF_cog_t),
                     names_to = "domain",
                     names_prefix = "BRIEF_",
                     values_to = "brief") %>%
dplyr::mutate(domain = factor(domain,
                       levels = c("bx_t", "emot_t", "cog_t"),
                       label = c("Behavior",
                                   "Emotion",
                                   "Cognitive"))) %>%
dplyr::select(ID, domain, brief, everything())

nrow(data_long)

[1] 195

nrow(data_long)/3

[1] 65
```
Complete Cases

n = 34 kids x 3-Brief = 102 lines

data_comp <- data_long %>%
dplyr::filter(complete.cases(brief, domain,
    C3P_hyp_t, asrs_soccomm_t, C3P_inatt_t,
    asrs_unbx_t, combined_fsiq,
    covid_onset, child_sex, child_age_yrs))

nrow(data_comp)

[1] 102

nrow(data_comp)/3

[1] 34
Multiple Imputations

Initiate

```r
ini <- mice::mice(data = data_wide_raw %>%
  dplyr::select(-starts_with("brief2")),
  m = 1,
  maxit = 0)
pred1 <- ini$predictorMatrix
```

“Mids” Format

```r
data_wide_mids <- mice::mice(data = data_wide_raw %>%
  dplyr::select(-starts_with("brief2")),
  m = 500,
  pred = pred1,
  seed = 1234)
```

“Mild” Format

```r
data_wide_mild <- mice::complete(data = data_wide_mids,
  action = "all",
  include = FALSE)
```

Wide-Long Format (all the imputed dataset are in a single dataframe)

```r
data_wide_long <- mice::complete(data = data_wide_mids,
  action = "long",
  include = TRUE)
```

LONG-Long format

```r
data_long_long <- data_wide_long %>%
  tidyr::pivot_longer(cols = c(BRIEF_bx_t, BRIEF_emot_t, BRIEF_cog_t),
  names_to = "domain",
  names_prefix = "BRIEF_",
  values_to = "brief") %>%
dplyr::mutate(domain = factor(domain))
```
Long mids

```r
data_long_list <- data_long_long %>%
dplyr::filter(.imp > 0) %>%
split(f = .$.imp)

data_long_mids <- miceadds::datalist2mids(data_long_list)

List of Long Mids

implist <- mitml::mids2mitml.list(data_long_mids)
```
Exploratory Data Analysis

Note: no imputations used here

Child Demographics

data_clean_main_all %>%
dplyr::mutate(child_sex = child_sex %>%
forcats::fct_recode("Not Available" = "Transgender")) %>%
furniture::table1("Behavior Regulation Index" = BRIEF_bx_t,
"Inhibit" = brief2inhts,
"Self-Monitor" = brief2smts,
"Emotion Regulation Index" = BRIEF_emot_t,
"Shift" = brief2sts,
"Emotional Control" = brief2ects,
"Cognitive Regulation Index" = BRIEF_cog_t,
"Initiate" = brief2inits,
"Working Memory" = brief2wmts,
"Plan/Organize" = brief2pots,
"Task-Monitor" = brief2tmts,
"Organization of Materials" = brief2omts,
"Global Executive Composite" = brief2gects,
splitby = ~ child_sex,
total = TRUE,
# test = TRUE,
na.rm = FALSE,
digits = 2,
output = "markdown",
caption = "Summary of the Behavior Rating Inventory of Executive Function, Second"

Table 1: Summary of the Behavior Rating Inventory of Executive Function, Second Edition (BRIEF-2) T-Scores

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Female</th>
<th>Male</th>
<th>Not Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavior Regulation Index</td>
<td>n = 65</td>
<td>n = 15</td>
<td>n = 47</td>
<td>n = 3</td>
</tr>
<tr>
<td>Inhibit</td>
<td>70.71 (9.62)</td>
<td>73.44 (10.85)</td>
<td>69.94 (9.29)</td>
<td>NaN ( NA)</td>
</tr>
<tr>
<td>Self-Monitor</td>
<td>69.71 (10.40)</td>
<td>73.00 (12.83)</td>
<td>68.78 (9.65)</td>
<td>NaN ( NA)</td>
</tr>
<tr>
<td>Emotion Regulation Index</td>
<td>68.51 (9.09)</td>
<td>67.67 (8.89)</td>
<td>68.75 (9.27)</td>
<td>NaN ( NA)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Female</td>
<td>Male</td>
<td>Not Available</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td>---------------</td>
</tr>
<tr>
<td><strong>Shift</strong></td>
<td>76.10 (8.56)</td>
<td>78.67 (9.64)</td>
<td>75.38 (8.25)</td>
<td>NaN ( NA)</td>
</tr>
<tr>
<td><strong>Emotional Control</strong></td>
<td>78.37 (8.65)</td>
<td>78.00 (10.72)</td>
<td>78.47 (8.17)</td>
<td>NaN ( NA)</td>
</tr>
<tr>
<td><strong>Cognitive Regulation Index</strong></td>
<td>70.02 (9.10)</td>
<td>71.89 (7.24)</td>
<td>69.50 (9.59)</td>
<td>NaN ( NA)</td>
</tr>
<tr>
<td><strong>Initiate</strong></td>
<td>66.54 (8.62)</td>
<td>67.67 (7.84)</td>
<td>66.22 (8.92)</td>
<td>NaN ( NA)</td>
</tr>
<tr>
<td><strong>Working Memory</strong></td>
<td>66.37 (9.06)</td>
<td>69.78 (6.61)</td>
<td>65.41 (9.51)</td>
<td>NaN ( NA)</td>
</tr>
<tr>
<td><strong>Plan/Organize</strong></td>
<td>67.44 (9.57)</td>
<td>66.89 (9.06)</td>
<td>67.59 (9.84)</td>
<td>NaN ( NA)</td>
</tr>
<tr>
<td><strong>Task-Monitor</strong></td>
<td>65.24 (9.25)</td>
<td>65.11 (6.92)</td>
<td>65.28 (9.91)</td>
<td>NaN ( NA)</td>
</tr>
<tr>
<td><strong>Organization of Materials</strong></td>
<td>59.54 (9.23)</td>
<td>56.78 (10.41)</td>
<td>60.31 (8.90)</td>
<td>NaN ( NA)</td>
</tr>
<tr>
<td><strong>Global Executive Composite</strong></td>
<td>63.46 (8.64)</td>
<td>61.44 (9.19)</td>
<td>64.03 (8.55)</td>
<td>NaN ( NA)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>73.34 (8.23)</td>
<td>72.44 (6.02)</td>
<td>73.59 (8.81)</td>
<td>NaN ( NA)</td>
</tr>
</tbody>
</table>
```r
data_clean_main_all %>%
dplyr::select("Child Age" = child_age_yrs,
              "ASRS Total" = asrs_total_t,
              "ASRS Social/Communication" = asrs_soccomm_t,
              "ASRS Unusual Behaviors" = asrs_unbx_t,
              "Conners 3P Inattention" = C3P_inatt_t,
              "Conners 3P Hyperactivity/Impulsivity" = C3P_hyp_t,
              "BRIEF-2 Behavior Regulation" = BRIEF_bx_t,
              "BRIEF-2 Emotion Regulation" = BRIEF_emot_t,
              "BRIEF-2 Cognitive Regulation" = BRIEF_cog_t,
              "WISC-V FSIQ" = WISC_fsiq_cs,
              "WASI-II FSIQ4" = WASI_fsiq_cs,
              "WAIS-IV FSIQ" = WAIS_fsiq_cs,
              "WPPSI-IV FSIQ" = WPPSI_fsiq_cs,
              "Combined FSIQ" = combined_fsiq)
%>% psych::describe() %>%
data.frame() %>%
dplyr::select(N = n, M = mean, Mdn = median, SD = sd, Min = min, Max = max)
%>% pander::pander(caption = "Basic Summary")
```

**Table 2: Basic Summary**

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>M</th>
<th>Mdn</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Age</td>
<td>65</td>
<td>10.69</td>
<td>10.49</td>
<td>3.205</td>
<td>6.247</td>
<td>17.28</td>
</tr>
<tr>
<td>ASRS Total</td>
<td>46</td>
<td>69.72</td>
<td>70.5</td>
<td>6.08</td>
<td>56</td>
<td>80</td>
</tr>
<tr>
<td>ASRS Social/Communication</td>
<td>46</td>
<td>66.07</td>
<td>67</td>
<td>7.973</td>
<td>48</td>
<td>85</td>
</tr>
<tr>
<td>ASRS Unusual Behaviors</td>
<td>47</td>
<td>68.11</td>
<td>69</td>
<td>5.824</td>
<td>52</td>
<td>79</td>
</tr>
<tr>
<td>Conners 3P Inattention</td>
<td>50</td>
<td>73.3</td>
<td>76.5</td>
<td>12.97</td>
<td>37</td>
<td>90</td>
</tr>
<tr>
<td>Conners 3P Hyperactivity/Impulsivity</td>
<td>50</td>
<td>77.14</td>
<td>80.5</td>
<td>12.04</td>
<td>36</td>
<td>90</td>
</tr>
<tr>
<td>BRIEF-2 Behavior Regulation</td>
<td>41</td>
<td>70.71</td>
<td>71</td>
<td>9.621</td>
<td>49</td>
<td>86</td>
</tr>
<tr>
<td>BRIEF-2 Emotion Regulation</td>
<td>41</td>
<td>76.1</td>
<td>75</td>
<td>8.561</td>
<td>50</td>
<td>94</td>
</tr>
<tr>
<td>BRIEF-2 Cognitive Regulation</td>
<td>41</td>
<td>66.54</td>
<td>65</td>
<td>8.623</td>
<td>46</td>
<td>81</td>
</tr>
<tr>
<td>WISC-V FSIQ</td>
<td>37</td>
<td>100.5</td>
<td>103</td>
<td>19.08</td>
<td>62</td>
<td>135</td>
</tr>
<tr>
<td>WASI-II FSIQ4</td>
<td>15</td>
<td>99.73</td>
<td>103</td>
<td>18.35</td>
<td>59</td>
<td>124</td>
</tr>
<tr>
<td>WAIS-IV FSIQ</td>
<td>2</td>
<td>97</td>
<td>97</td>
<td>18.38</td>
<td>84</td>
<td>110</td>
</tr>
<tr>
<td>WPPSI-IV FSIQ</td>
<td>2</td>
<td>80</td>
<td>80</td>
<td>5.657</td>
<td>76</td>
<td>84</td>
</tr>
<tr>
<td>Combined FSIQ</td>
<td>56</td>
<td>99.45</td>
<td>103</td>
<td>18.59</td>
<td>59</td>
<td>135</td>
</tr>
</tbody>
</table>
Parent Demographics

data_clean_main_all %>%
furniture::table1("Relationship to Child" = parent1_rel, 
    "Gender" = parent1_gender, 
    "Marital Status" = marital_status, 
    "Family Income" = income, 
    "Education" = parent1_ed, 
    "Employment" = parent1_employment, 
    "Family History of Mental Health" = mhealth, 
    total = TRUE, 
    na.rm = FALSE, 
    digits = 2, 
    output = "markdown", 
    caption = "Parent Demographics")

Table 3: Parent Demographics

<table>
<thead>
<tr>
<th></th>
<th>Mean/Count (SD/%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>n = 65</strong></td>
<td></td>
</tr>
<tr>
<td>Relationship to Child</td>
<td></td>
</tr>
<tr>
<td>Father</td>
<td>3 (4.6%)</td>
</tr>
<tr>
<td>Mother</td>
<td>26 (40%)</td>
</tr>
<tr>
<td>NA</td>
<td>36 (55.4%)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>23 (35.4%)</td>
</tr>
<tr>
<td>Male</td>
<td>3 (4.6%)</td>
</tr>
<tr>
<td>NA</td>
<td>39 (60%)</td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
</tr>
<tr>
<td>Divorced or separated</td>
<td>4 (6.2%)</td>
</tr>
<tr>
<td>Married</td>
<td>39 (60%)</td>
</tr>
<tr>
<td>Never married or single</td>
<td>2 (3.1%)</td>
</tr>
<tr>
<td>Other</td>
<td>3 (4.6%)</td>
</tr>
<tr>
<td>Separated</td>
<td>1 (1.5%)</td>
</tr>
<tr>
<td>Not available</td>
<td>1 (1.5%)</td>
</tr>
<tr>
<td>Divorced</td>
<td>1 (1.5%)</td>
</tr>
<tr>
<td>NA</td>
<td>14 (21.5%)</td>
</tr>
<tr>
<td>Family Income</td>
<td></td>
</tr>
<tr>
<td>$38,701-$82,500</td>
<td>10 (15.4%)</td>
</tr>
<tr>
<td>$82,501-$157,500</td>
<td>9 (13.8%)</td>
</tr>
<tr>
<td>$9,526-$38,700</td>
<td>7 (10.8%)</td>
</tr>
<tr>
<td>NA</td>
<td>39 (60%)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>Bachelor’s Degree</td>
<td>11 (16.9%)</td>
</tr>
<tr>
<td>Doctorate</td>
<td>1 (1.5%)</td>
</tr>
<tr>
<td>Category</td>
<td>Mean/Count (SD/%)</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>High School or GED</td>
<td>4 (6.2%)</td>
</tr>
<tr>
<td>Professional Degree</td>
<td>2 (3.1%)</td>
</tr>
<tr>
<td>Some College</td>
<td>8 (12.3%)</td>
</tr>
<tr>
<td>NA</td>
<td>39 (60%)</td>
</tr>
<tr>
<td>Employment</td>
<td></td>
</tr>
<tr>
<td>Employed full time (40 or more hours per week)</td>
<td>8 (12.3%)</td>
</tr>
<tr>
<td>Employed part time (less than 35 hours per week)</td>
<td>5 (7.7%)</td>
</tr>
<tr>
<td>Homemaker</td>
<td>13 (20%)</td>
</tr>
<tr>
<td>Unable to work</td>
<td>1 (1.5%)</td>
</tr>
<tr>
<td>Unemployed and not currently looking for work</td>
<td>1 (1.5%)</td>
</tr>
<tr>
<td>NA</td>
<td>37 (56.9%)</td>
</tr>
<tr>
<td>Family History of Mental Health</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>9 (13.8%)</td>
</tr>
<tr>
<td>Yes</td>
<td>20 (30.8%)</td>
</tr>
<tr>
<td>NA</td>
<td>36 (55.4%)</td>
</tr>
</tbody>
</table>
## Race/Ethnicity

```r
data_clean_main_all %>%
dplyr::mutate(child_sex = child_sex %>%
               forcats::fct_recode("Not Available" = "Transgender")) %>%
table1("Child Native American" = child_ai,
        "Child Asian" = child_asian,
        "Child Black/African American" = child_black,
        "Child Latinx" = child_lx,
        "Child White" = child_white,
        "Child Arabian" = child_arab,
        "Child Pacific Islander" = child_pac_isl,
        "Child Multiracial" = child_multi,
        "Child Race/Ethnicity Other" = child_race_other,
        "Child Race Declined" = child_race_decline,
        "Child Race Unknown" = child_race_unk,
        "Parent Native American" = parent_ai,
        "Parent Aisain" = parent_asian,
        "Parent Black/African American" = parent_black,
        "Parent Latinx" = parent_lx,
        "Parent White" = parent_white,
        "Parent Race/Ethnicity Other" = parent_race_other,
        splitby = ~ child_sex,
        total = TRUE,
        test = FALSE,
        na.rm = FALSE,
        digits = 2,
        caption = "Race/Ethnicity")
```

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>child_sex</th>
<th>Total</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male Not Available</td>
<td>n = 65</td>
<td>n = 15</td>
<td>n = 47</td>
</tr>
<tr>
<td>Child Native American</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unchecked</td>
<td>65 (100%)</td>
<td>15 (100%)</td>
<td>47 (100%)</td>
</tr>
<tr>
<td>NA</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Child Asian</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unchecked</td>
<td>43 (66.2%)</td>
<td>10 (66.7%)</td>
<td>33 (70.2%)</td>
</tr>
<tr>
<td>NA</td>
<td>22 (33.8%)</td>
<td>5 (33.3%)</td>
<td>14 (29.8%)</td>
</tr>
<tr>
<td>Child Black/African American</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unchecked</td>
<td>64 (98.5%)</td>
<td>15 (100%)</td>
<td>46 (97.9%)</td>
</tr>
<tr>
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<td>1 (2.1%)</td>
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<td>0 (0%)</td>
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<td>62 (95.4%)</td>
<td>15 (100%)</td>
<td>44 (93.6%)</td>
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<td>9 (60%)</td>
<td>29 (61.7%)</td>
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<tr>
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<td>24 (36.9%)</td>
<td>6 (40%)</td>
<td>18 (38.3%)</td>
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<tr>
<td>Child Arabian</td>
<td>24 (36.9%)</td>
<td>6 (40%)</td>
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</tr>
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<td>0 (0%)</td>
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<tr>
<td>Child Pacific Islander</td>
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<td>5 (33.3%)</td>
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<td>10 (66.7%)</td>
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<td>Child Multiracial</td>
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<td>5 (33.3%)</td>
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<td>NA</td>
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<tr>
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<td>3 (20%)</td>
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<td>Parent Aisain</td>
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<tr>
<td>Parent Latinx</td>
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<td>Parent White</td>
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<tr>
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<td>4 (26.7%)</td>
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<tr>
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<td>43 (66.2%)</td>
<td>10 (66.7%)</td>
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<td>NA</td>
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<td>5 (33.3%)</td>
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</table>
Participant Measure Scores

Autism Spectrum Rating Scales (ASRS)

data_clean_main_all %>%
dplyr::mutate(child_sex = child_sex %>%
  forcats::fct_recode("Not Available" = "Transgender")) %>%
furniture::table1("Total" = asrs_total_t,
  "SC - Social Communication" = asrs_soccomm_t,
  "UB - Unusual Behaviors" = asrs_unbx_t,
  "SR - Self-Regulation" = asrs_sr_t,
  "DSM-IV" = asrs_dsm_t,
  "PS - Peer Socialization" = asrs_peersoc_t,
  "AS - Adult Socialization" = asrs_adsoc_t,
  "SER - Social Emotional Reciprocity" = asrs_socemorec_t,
  "AL - Atypical Language" = asrs_atylang_t,
  "ST - Sterotypy" = asrs_stereo_t,
  "SR - Behavioral Rigidity" = asrs_bxrig_t,
  "SS - Sensory Sensitivity" = asrs_sensen_t,
  "AT - Attention" = asrs_attn_t,
  splitby = ~ child_sex,
  total = TRUE,
  test = FALSE,
  na.rm = FALSE,
  digits = 2,
  caption = "Summary of ASRS Scores")

Summary of ASRS Scores

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<th>child_sex</th>
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<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 65</td>
<td>n = 15</td>
<td>n = 47</td>
</tr>
<tr>
<td>Total</td>
<td>69.72 (6.08)</td>
<td>68.22 (5.54)</td>
<td>70.08 (6.31)</td>
</tr>
<tr>
<td>SC - Social Communication</td>
<td>66.07 (7.97)</td>
<td>65.33 (4.27)</td>
<td>66.28 (6.79)</td>
</tr>
<tr>
<td>UB - Unusual Behaviors</td>
<td>68.11 (5.82)</td>
<td>69.00 (8.09)</td>
<td>67.84 (5.33)</td>
</tr>
<tr>
<td>SR - Self-Regulation</td>
<td>65.62 (6.27)</td>
<td>62.56 (4.82)</td>
<td>66.43 (6.47)</td>
</tr>
<tr>
<td>DSM-IV</td>
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<td>71.22 (7.48)</td>
<td>70.78 (7.04)</td>
</tr>
<tr>
<td>Scale</td>
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<td>Mean (SD) 2</td>
<td>Mean (SD) 3</td>
</tr>
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<td>-------------------</td>
<td>-------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>AS - Adult Socialization</strong></td>
<td>68.79 (7.56)</td>
<td>70.44 (5.41)</td>
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</tr>
<tr>
<td><strong>SER - Social Emotional Reciprocity</strong></td>
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<td>64.67 (3.74)</td>
<td>68.73 (8.02)</td>
</tr>
<tr>
<td><strong>AL - Atypical Language</strong></td>
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<td>63.67 (4.95)</td>
<td>67.34 (7.87)</td>
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<tr>
<td><strong>ST - Sterotypy</strong></td>
<td>64.30 (8.12)</td>
<td>64.67 (8.49)</td>
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<tr>
<td><strong>SR - Behavioral Rigidity</strong></td>
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<td>63.78 (8.17)</td>
<td>61.19 (8.45)</td>
</tr>
<tr>
<td><strong>SS - Sensory Sensitivity</strong></td>
<td>69.11 (6.97)</td>
<td>68.00 (6.80)</td>
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<tr>
<td><strong>AT - Attention</strong></td>
<td>70.21 (9.17)</td>
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**Not Available**

n = 3

70.00 (NA)

65.00 (NA)

70.00 (NA)

63.00 (NA)

72.00 (NA)

74.00 (NA)

71.00 (NA)

66.00 (NA)

63.00 (NA)

63.00 (NA)

74.00 (NA)

74.00 (NA)

57.00 (NA)
Behavior Rating Inventory of Executive Function, Second Edition (BRIEF-2)

data_clean_main_all %>%
dplyr::mutate(child_sex = child_sex %>%
forcats::fct_recode("Not Available" = "Transgender")) %>%
furniture::table1("Behavior Regulation Index" = BRIEF_bx_t,
"Inhibit" = brief2inhts,
"Self-Monitor" = brief2smts,
"Emotion Regulation Index" = BRIEF_emot_t,
"Shift" = brief2sts,
"Emotional Control" = brief2ects,
"Cognitive Regulation Index" = BRIEF_cog_t,
"Initiate" = brief2inits,
"Working Memory" = brief2wmts,
"Plan/Organize" = brief2pots,
"Task-Monitor" = brief2tmts,
"Organization of Materials" = brief2omts,
"Global Executive Composite" = brief2gects,
splitby = ~ child_sex,
total = TRUE,
test = FALSE,
na.rm = FALSE,
digits = 2,
caption = "Summary of BRIEF-2 Scores")

Summary of BRIEF-2 Scores

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<td>Male</td>
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<td>n = 65</td>
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<td>69.94 (9.29)</td>
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</tr>
<tr>
<td></td>
<td>69.71 (10.40)</td>
<td>73.00 (12.83)</td>
<td>68.78 (9.65)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>68.51 (9.09)</td>
<td>67.67 (8.89)</td>
<td>68.75 (9.27)</td>
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</tr>
<tr>
<td></td>
<td>76.10 (8.56)</td>
<td>78.67 (9.64)</td>
<td>75.38 (8.25)</td>
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</tr>
<tr>
<td></td>
<td>78.37 (8.65)</td>
<td>78.00 (10.72)</td>
<td>78.47 (8.17)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>70.02 (9.10)</td>
<td>71.89 (7.24)</td>
<td>69.50 (9.59)</td>
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<td></td>
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<tr>
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<td>69.94 (9.29)</td>
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</tr>
<tr>
<td>Inhibit</td>
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<td>73.00 (12.83)</td>
<td>68.78 (9.65)</td>
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</tr>
<tr>
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<td>67.67 (8.89)</td>
<td>68.75 (9.27)</td>
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</tr>
<tr>
<td>Emotion Regulation Index</td>
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<td>78.67 (9.64)</td>
<td>75.38 (8.25)</td>
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</tr>
<tr>
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<td>78.47 (8.17)</td>
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</tr>
<tr>
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<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
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</tr>
<tr>
<td>-----------------------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>Initiate</td>
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</tr>
<tr>
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<td>65.41 (9.51)</td>
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<tr>
<td>Plan/Organize</td>
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<td>66.89 (9.06)</td>
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</tr>
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<td>Task-Monitor</td>
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<td>65.11 (6.92)</td>
<td>65.28 (9.91)</td>
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</tr>
<tr>
<td>Organization of Materials</td>
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<td>56.78 (10.41)</td>
<td>60.31 (8.90)</td>
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<td>Global Executive Composite</td>
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<td>64.03 (8.55)</td>
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<td>Not Available</td>
<td>73.34 (8.23)</td>
<td>72.44 (6.02)</td>
<td>73.59 (8.81)</td>
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n = 3

NaN ( NA)
Conners Rating Scales, Third Edition, Parent Form (Conners 3P)

```r
data_clean_main_all %>%
dplyr::mutate(  
  child_sex = child_sex %>%
  forcats::fct_recode("Not Available" = "Transgender")) %>%
  furniture::table1("Inattention" = C3P_inatt_t,  
  "Hyperactivity/Impulsivity" = C3P_hyp_t,  
  "Learning Problems" = c3plpts,  
  "Executive Functioning" = c3pefts,  
  "Defiance/Aggression" = c3pdats,  
  "Peer Relations" = c3pprts,  
  splitby = ~ child_sex,  
  total = TRUE,  
  test = FALSE,  
  na.rm = FALSE,  
  digits = 2,  
  caption = "Summary of Conners 3P Scores")
```

Summary of Conners 3P Scores

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<th>Male</th>
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<tbody>
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</tr>
<tr>
<td><strong>n = 47</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Inattention</strong></td>
<td>73.30 (12.97)</td>
<td>75.64 (7.71)</td>
<td>72.81 (14.68)</td>
</tr>
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<td>78.91 (11.67)</td>
<td>76.83 (12.53)</td>
</tr>
<tr>
<td><strong>Learning Problems</strong></td>
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<td>63.82 (14.78)</td>
<td>61.00 (14.15)</td>
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<td>72.00 (11.20)</td>
<td>66.56 (13.80)</td>
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<td>64.36 (15.96)</td>
<td>71.81 (18.31)</td>
</tr>
<tr>
<td><strong>Peer Relations</strong></td>
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<td>79.18 (13.39)</td>
<td>77.94 (14.34)</td>
</tr>
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<tr>
<td>78.33</td>
<td>11.50</td>
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</tbody>
</table>
Intelligence Tests

data_clean_main_all %>%
dplyr::mutate(child_sex = child_sex %>%
 forcats::fct_recode("Not Available" = "Transgender")) %>%
furniture::table1("Combined FSIQ" = combined_fsiq,
  "WISC-V FSIQ" = WISC_fsiq_cs,
  "WASI-II FSIQ" = WASI_fsiq_cs,
  "WAIS-IV FSIQ" = WAIS_fsiq_cs,
  "WPPSI-IV FSIQ" = WPPSI_fsiq_cs,
  splitby = ~ child_sex,
  total = TRUE,
  test = FALSE,
  na.rm = FALSE,
  digits = 2,
  caption = "Summary of FSIQ Scores by Intelligence Test")

Summary of FSIQ Scores by Intelligence Test

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<td>n = 15</td>
<td>n = 47</td>
<td>n = 3</td>
</tr>
<tr>
<td>Combined FSIQ</td>
<td>99.45 (18.59)</td>
<td>105.43 (17.84)</td>
<td>96.33 (18.83)</td>
<td>112.00 (4.36)</td>
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<tr>
<td>WISC-V FSIQ</td>
<td>100.51 (19.08)</td>
<td>112.88 (17.36)</td>
<td>95.93 (18.47)</td>
<td>113.00 (5.66)</td>
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<tr>
<td>WASI-II FSIQ</td>
<td>99.73 (18.35)</td>
<td>97.80 (14.46)</td>
<td>100.70 (20.68)</td>
<td>NaN (NA)</td>
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<tr>
<td>WAIS-IV FSIQ</td>
<td>97.00 (18.38)</td>
<td>NaN (NA)</td>
<td>84.00 (NA)</td>
<td>110.00 (NA)</td>
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<tr>
<td>WPPSI-IV FSIQ</td>
<td>80.00 (5.66)</td>
<td>84.00 (NA)</td>
<td>76.00 (NA)</td>
<td>NaN (NA)</td>
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Univariate Visualizations

Child Age by Gender

data_clean_main_all %>%
dplyr::filter(complete.cases(child_age_yrs, child_sex)) %>%
dplyr::filter(child_sex %in% c("Male", "Female")) %>%
ggplot(aes(child_age_yrs)) +
geom_density(fill = "black",
alpha = .4) +
theme_bw() +
geom_vline(data = . %>%
dplyr::group_by(child_sex) %>%
dplyr::summarise(mean = mean(child_age_yrs)) %>%
dplyr::ungroup(),
aes(xintercept = mean)) +
facet_wrap(~ child_sex, ncol = 1) +
labs(x = "Child Age",
y = "Density")

Figure 1: Distribution of Child Ages by Gender
Social-communication Skills

data_clean_main_all %>%
ggplot(aes(asrs_soccomm_t)) +
  geom_density(fill = "gray",
              alpha = .5) +
  geom_vline(aes(xintercept = mean(asrs_soccomm_t, 
                 na.rm = TRUE),
              #color = "Mean",
              linetype = "Mean",
              size = "Mean",
              alpha = "Mean")) +
  geom_vline(aes(xintercept = median(asrs_soccomm_t, 
                 na.rm = TRUE),
              #color = "Median",
              linetype = "Median",
              size = "Median",
              alpha = "Median")) +
  geom_vline(aes(xintercept = quantile(asrs_soccomm_t, 
                 p = c(.25),
                 na.rm = TRUE),
              #color = "25th Percentile",
              linetype = "25th Percentile",
              size = "25th Percentile",
              alpha = "25th Percentile")) +
  geom_vline(aes(xintercept = quantile(asrs_soccomm_t, 
                 p = c(.75),
                 na.rm = TRUE),
              #color = "75th Percentile",
              linetype = "75th Percentile",
              size = "75th Percentile",
              alpha = "75th Percentile")) +
  theme_bw() +
  labs(x = "ASRS Social Communication",
       y = "Density",
       linetype = NULL,
       color = NULL,
       size = NULL,
       alpha = NULL) +
  scale_linetype_manual(values = c("25th Percentile" = "longdash",
                                     "Mean" = "solid",
                                     "Median" = "solid",
                                     "75th Percentile" = "longdash")) +
  # scale_color_manual(values = c("25th Percentile" = "gray30",
  # "Mean" = "red",
  # "Median" = "blue",
  # "75th Percentile" = "gray30")) +
scale_size_manual(values = c("25th Percentile" = .75,
  "Mean" = 3,
  "Median" = 1,
  "75th Percentile" = .75)) +
scale_alpha_manual(values = c("25th Percentile" = .5,
  "Mean" = 1,
  "Median" = 1,
  "75th Percentile" = .7)) +
guides(fill = FALSE) +
theme(legend.key = element_rect(fill = "white",
  color = "white"),
  legend.key.height = unit(1, "cm"),
  legend.position = "bottom")

Figure 2: Distribution of ASRS Social Communication Skills
Unusual Behaviors

data_clean_main_all %>%
ggplot(aes(asrs_unbx_t)) +
  geom_density(fill = "gray",
               alpha = .5) +
  geom_vline(aes(xintercept = mean(asrs_unbx_t, na.rm = TRUE),
                # color = "Mean",
                linetype = "Mean",
                size = "Mean",
                alpha = "Mean")) +
  geom_vline(aes(xintercept = median(asrs_unbx_t, na.rm = TRUE),
                # color = "Median",
                linetype = "Median",
                size = "Median",
                alpha = "Median")) +
  geom_vline(aes(xintercept = quantile(asrs_unbx_t, p = c(.25),
                                     na.rm = TRUE),
                # color = "25th Percentile",
                linetype = "25th Percentile",
                size = "25th Percentile",
                alpha = "25th Percentile")) +
  geom_vline(aes(xintercept = quantile(asrs_unbx_t, p = c(.75),
                                     na.rm = TRUE),
                # color = "75th Percentile",
                linetype = "75th Percentile",
                size = "75th Percentile",
                alpha = "75th Percentile")) +
  theme_bw() +
  labs(x = "ASRS Unusual Behavior",
       y = "Density",
       linetype = NULL,
       color = NULL,
       size = NULL,
       alpha = NULL) +
  scale_linetype_manual(values = c("25th Percentile" = "longdash",
                                   "Mean" = "solid",
                                   "Median" = "solid",
                                   "75th Percentile" = "longdash")) +
  # scale_color_manual(values = c("25th Percentile" = "gray30",
  #                           "Mean" = "red",
  #                           "Median" = "blue",
  #                           "75th Percentile" = "gray30")) +
scale_size_manual(values = c("25th Percentile" = .75, "Mean" = 3, "Median" = 1, "75th Percentile" = .75)) +
scale_alpha_manual(values = c("25th Percentile" = .5, "Mean" = .75, "Median" = 1.5, "75th Percentile" = .7)) +
guides(fill = FALSE) +
theme(legend.key = element_rect(fill = "white", color = "white"),
       legend.key.height = unit(1, "cm"),
       legend.position = "bottom")

Figure 3: Distribution of ASRS Unusual Behaviors
Hyperactivity

data_clean_main_all %>%
  ggplot(aes(C3P_hyp_t)) +
  geom_density(fill = "gray",
               alpha = .5) +
  geom_vline(aes(xintercept = mean(C3P_hyp_t,
                          na.rm = TRUE),
              # color = "Mean",
              linetype = "Mean",
              size = "Mean",
              alpha = "Mean")) +
  geom_vline(aes(xintercept = median(C3P_hyp_t,
                          na.rm = TRUE),
              # color = "Median",
              linetype = "Median",
              size = "Median",
              alpha = "Median")) +
  geom_vline(aes(xintercept = quantile(C3P_hyp_t,
                          p = c(.25),
                          na.rm = TRUE),
              # color = "25th Percentile",
              linetype = "25th Percentile",
              size = "25th Percentile",
              alpha = "25th Percentile")) +
  geom_vline(aes(xintercept = quantile(C3P_hyp_t,
                          p = c(.75),
                          na.rm = TRUE),
              # color = "75th Percentile",
              linetype = "75th Percentile",
              size = "75th Percentile",
              alpha = "75th Percentile")) +
  theme_bw() +
  labs(x = "Conners 3P Hyperactivity/Impulsivity",
       y = "Density",
       linetype = NULL,
       color = NULL,
       size = NULL,
       alpha = NULL) +
  scale_linetype_manual(values = c("25th Percentile" = "longdash",
                                   "Mean" = "solid",
                                   "Median" = "solid",
                                   "75th Percentile" = "longdash")) +
  scale_color_manual(values = c("25th Percentile" = "gray30",
                                "Mean" = "red",
                                "Median" = "blue",
                                "75th Percentile" = "gray30")) +
scale_size_manual(values = c("25th Percentile" = .75, "Mean" = 3, "Median" = 1, "75th Percentile" = .75)) +
scale_alpha_manual(values = c("25th Percentile" = .5, "Mean" = .75, "Median" = 1.5, "75th Percentile" = .7)) +
guides(fill = FALSE) +
theme(legend.key = element_rect(fill = "white", color = "white"),
      legend.key.height = unit(1, "cm"),
      legend.position = "bottom")

Figure 4: Distribution of Conners 3P Hyperactivity Impulsivity
Executive Functioning

data_clean_main_all %>%
ggplot(aes(BRIEF_bx_t)) +
geom_density(fill = "gray",
alpha = .5) +
geom_vline(aes(xintercept = mean(BRIEF_bx_t, na.rm = TRUE),
  # color = "Mean",
  linetype = "Mean",
  size = "Mean",
  alpha = "Mean")) +
geom_vline(aes(xintercept = median(BRIEF_bx_t, na.rm = TRUE),
  # color = "Median",
  linetype = "Median",
  size = "Median",
  alpha = "Median")) +
geom_vline(aes(xintercept = quantile(BRIEF_bx_t, p = c(.25), na.rm = TRUE),
  # color = "25th Percentile",
  linetype = "25th Percentile",
  size = "25th Percentile",
  alpha = "25th Percentile")) +
geom_vline(aes(xintercept = quantile(BRIEF_bx_t, p = c(.75), na.rm = TRUE),
  # color = "75th Percentile",
  linetype = "75th Percentile",
  size = "75th Percentile",
  alpha = "75th Percentile")) +
theme_bw() +
labs(x = "BRIEF-2 Behavior Regulation",
y = "Density",
linetype = NULL,
color = NULL,
size = NULL,
alpha = NULL) +
scale_linetype_manual(values = c("25th Percentile" = "longdash",
  "Mean" = "solid",
  "Median" = "solid",
  "75th Percentile" = "longdash")) +
# scale_color_manual(values = c("25th Percentile" = "gray30",
#  "Mean" = "red",
#  "Median" = "blue",
Figure 5: Distribution of BRIEF-2 Behavior Regulation

Behavior Regulation
```r
data_clean_main_all %>%
  ggplot(aes(BRIEF_emot_t)) +
  geom_density(fill = "gray",
               alpha = .5) +
  geom_vline(aes(xintercept = mean(BRIEF_emot_t, na.rm = TRUE),
                # color = "Mean",
                linetype = "Mean",
                size = "Mean",
                alpha = "Mean")) +
  geom_vline(aes(xintercept = median(BRIEF_emot_t, na.rm = TRUE),
                # color = "Mean",
                linetype = "Median",
                size = "Median",
                alpha = "Median")) +
  geom_vline(aes(xintercept = quantile(BRIEF_emot_t, p = c(.25),
                                       na.rm = TRUE),
                # color = "25th Percentile",
                linetype = "25th Percentile",
                size = "25th Percentile",
                alpha = "25th Percentile")) +
  geom_vline(aes(xintercept = quantile(BRIEF_emot_t, p = c(.75),
                                       na.rm = TRUE),
                # color = "75th Percentile",
                linetype = "75th Percentile",
                size = "75th Percentile",
                alpha = "75th Percentile")) +
  theme_bw() +
  labs(x = "BRIEF-2 Emotion Regulation",
       y = "Density",
       linetype = NULL,
       color = NULL,
       size = NULL,
       alpha = NULL) +
  scale_linetype_manual(values = c("25th Percentile" = "longdash",
                                 "Mean" = "solid",
                                 "Median" = "solid",
                                 "75th Percentile" = "longdash")) +
  # scale_color_manual(values = c("25th Percentile" = "gray30",
  #                            "Mean" = "red",
  #                            "Median" = "blue",
  #                            "75th Percentile" = "gray30")) +
  scale_size_manual(values = c("25th Percentile" = .75,
                             "Mean" = 1,
                             "Median" = .5,
                             "75th Percentile" = .25))
```
Figure 6: Distribution of BRIEF-2 Behavior Regulation

Emotion Regulation
data_clean_main_all %>%
ggplot(aes(BRIEF_cog_t)) +
  geom_density(fill = "gray",
               alpha = .5) +
  geom_vline(aes(xintercept = mean(BRIEF_cog_t,
                           na.rm = TRUE),
             # color = "Mean",
             linetype = "Mean",
             size = "Mean",
             alpha = "Mean")) +
  geom_vline(aes(xintercept = median(BRIEF_cog_t,
                           na.rm = TRUE),
             # color = "Median",
             linetype = "Median",
             size = "Median",
             alpha = "Median")) +
  geom_vline(aes(xintercept = quantile(BRIEF_cog_t,
                          p = c(.25),
                          na.rm = TRUE),
             # color = "25th Percentile",
             linetype = "25th Percentile",
             size = "25th Percentile",
             alpha = "25th Percentile")) +
  geom_vline(aes(xintercept = quantile(BRIEF_cog_t,
                          p = c(.75),
                          na.rm = TRUE),
             # color = "75th Percentile",
             linetype = "75th Percentile",
             size = "75th Percentile",
             alpha = "75th Percentile")) +
  theme_bw() +
labs(x = "BRIEF-2 Cognitive Regulation",
       y = "Density",
       linetype = NULL,
       color = NULL,
       size = NULL,
       alpha = NULL) +
  scale_linetype_manual(values = c("25th Percentile" = "longdash",
                                "Mean" = "solid",
                                "Median" = "solid",
                                "75th Percentile" = "longdash")) +
  # scale_color_manual(values = c("25th Percentile" = "gray30", 
  # "Mean" = "red", 
  # "Median" = "blue", 
  # "75th Percentile" = "gray30")) +
  scale_size_manual(values = c("25th Percentile" = .75,
"Mean" = 3,
"Median" = 1,
"75th Percentile" = .75)) +
scale_alpha_manual(values = c("25th Percentile" = .5,
"Mean" = .75,
"Median" = 1.5,
"75th Percentile" = .7)) +
guides(fill = FALSE) +
theme(legend.key = element_rect(fill = "white",
     color = "white"),
     legend.key.height = unit(1, "cm"),
     legend.position = "bottom")

Figure 7: Distribution of BRIEF-2 Cognitive Regulation

Cognitive Regulation
Intellectual Functioning

data_clean_main_all %>%
ggplot(aes(combined_fsiq)) +
  geom_density(fill = "gray",
              alpha = .5) +
  geom_vline(aes(xintercept = mean(combined_fsiq,
                      na.rm = TRUE),
             # color = "Mean",
             linetype = "Mean",
             size = "Mean",
             alpha = "Mean")) +
  geom_vline(aes(xintercept = median(combined_fsiq,
                     na.rm = TRUE),
             # color = "Median",
             linetype = "Median",
             size = "Median",
             alpha = "Median")) +
  geom_vline(aes(xintercept = quantile(combined_fsiq,
                        p = c(.25),
                        na.rm = TRUE),
             # color = "25th Percentile",
             linetype = "25th Percentile",
             size = "25th Percentile",
             alpha = "25th Percentile")) +
  geom_vline(aes(xintercept = quantile(combined_fsiq,
                        p = c(.75),
                        na.rm = TRUE),
             # color = "75th Percentile",
             linetype = "75th Percentile",
             size = "75th Percentile",
             alpha = "75th Percentile")) +
  theme_bw() +
  labs(x = "Combined FSIQ",
       y = "Density",
       linetype = NULL,
       color = NULL,
       size = NULL,
       alpha = NULL) +
  scale_linetype_manual(values = c("25th Percentile" = "longdash",
                                  "Mean" = "solid",
                                  "Median" = "solid",
                                  "75th Percentile" = "longdash")) +
  # scale_color_manual(values = c("25th Percentile" = "gray30",
  #     "Mean" = "red",
  #     "Median" = "blue",
  #     "75th Percentile" = "gray30") +
scale_size_manual(values = c("25th Percentile" = .75,
                      "Mean" = 3,
                      "Median" = 1,
                      "75th Percentile" = .75)) +
scale_alpha_manual(values = c("25th Percentile" = .5,
                           "Mean" = .75,
                           "Median" = 1.5,
                           "75th Percentile" = .7)) +
guides(fill = FALSE) +
theme(legend.key = element_rect(fill = "white",
                                 color = "white"),
      legend.key.height = unit(1, "cm"),
      legend.position = "bottom")

![Graph showing distribution of Combined FSIQ](image)

**Figure 8:** Distribution of Combined FSIQ
Multivariate Visualizations

Scatterplots

Behavior Regulation and ASD Symptomology

data_clean_main_all %>%
dplyr::filter(complete.cases(asrs_total_t, BRIEF_bx_t)) %>%
ggplot(aes(x = asrs_total_t,
           y = BRIEF_bx_t,
           group = 1)) +
  geom_smooth(method = "lm",
              formula = y ~ x,
              color = "black") +
  geom_count() +
  theme_bw() +
  labs(x = "ASRS Total T-score",
       y = "BRIEF-2 Behavior Regulation T-score",
       size = "Count") +
ggpubr::stat_cor(p.digits = 5) +
scale_x_continuous(breaks = seq(from = 50, to = 80, by = 2)) +
scale_y_continuous(breaks = seq(from = 50, to = 80, by = 5))
Figure 9: Relationship Between ASRS Total Score and BRIEF-2 Behavior Regulation
```r
data_clean_main_all %>%
dplyr::filter(complete.cases(asrs_soccomm_t, BRIEF_bx_t)) %>%
ggplot(aes(x = asrs_soccomm_t, y = BRIEF_bx_t,
        group = 1)) +
geom_smooth(method = "lm",
        formula = y ~ x,
        color = "red") +
geom_count() +
theme_bw() +
labs(x = "ASRS Social/Communication T-score",
     y = "BRIEF-2 Behavior Regulation T-score",
     size = "Count") +
ggpubr::stat_cor(p.digits = 3) +
scale_x_continuous(breaks = seq(from = 50, to = 80, by = 2)) +
scale_y_continuous(breaks = seq(from = 50, to = 80, by = 5))
```

Figure 10: Relationship Between ASRS Social Communication and BRIEF-2 Behavior Regulation
data_clean_main_all %>%
dplyr::filter(complete.cases(asrs_unbx_t, BRIEF_bx_t)) %>%
ggplot(aes(x = asrs_unbx_t,
    y = BRIEF_bx_t,
    group = 1)) +
  geom_smooth(method = "lm",
              formula = y ~ x,
              color = "red") +
  geom_count() +
  theme_bw() +
  labs(x = "ASRS Unusual Behavior T-score",
       y = "BRIEF-2 Behavior Regulation T-score",
       size = "Count") +
  ggpubr::stat_cor() +
  scale_x_continuous(breaks = seq(from = 50, to = 80, by = 2)) +
  scale_y_continuous(breaks = seq(from = 50, to = 80, by = 5))

$R = 0.47$, $p = 0.0042$

Figure 11: Relationship Between ASRS Unusual Behavior and BRIEF-2 Behavior Regulation
data_clean_main_all %>%
dplyr::filter(complete.cases(C3P_hyp_t, BRIEF_bx_t)) %>%
ggplot(aes(x = C3P_hyp_t,
           y = BRIEF_bx_t,
           group = 1)) +
geom_smooth(method = "lm",
            formula = y ~ x,
            color = "red") +
geom_count() +
theme_bw() +
labs(x = "Conners 3P Hyperactivity/Impulsivity T-score",
     y = "BRIEF-2 Behavior Regulation T-score",
     size = "Count") +
ggpubr::stat_cor(p.digits = 5) +
scale_x_continuous(breaks = seq(from = 35, to = 95, by = 2))+
scale_y_continuous(breaks = seq(from = 40, to = 90, by = 5))

Figure 12: Relationship Between Conners 3P Hyperactivity/Impulsivity and BRIEF-2 Behavior Regulation
```
data_clean_main_all %>%
dplyr::filter(complete.cases(C3P_inatt_t, BRIEF_bx_t)) %>

ggplot(aes(x = C3P_inatt_t,
    y = BRIEF_bx_t,
    group = 1)) +
geom_smooth(method = "lm",
    formula = y ~ x,
    color = "red") +
geom_count() +
theme_bw() +
labs(x = "Conners 3P Inattention T-score",
    y = "BRIEF-2 Behavior Regulation T-score",
    size = "Count") +
ggpubr::stat_cor(p.digits = 3) +
scale_x_continuous(breaks = seq(from = 35, to = 95, by = 2)) +
scale_y_continuous(breaks = seq(from = 40, to = 90, by = 5))
```

Figure 13: Relationship Between Conners 3P Inattention and BRIEF-2 Behavior Regulation
```r
data_clean_main_all %>%
dplyr::filter(complete.cases(combined_fsiq, BRIEF_bx_t)) %>%
ggplot(aes(x = combined_fsiq,
         y = BRIEF_bx_t,
         group = 1)) +
geom_smooth(method = "lm",
            formula = y ~ x,
            color = "red") +
geom_count() +
theme_bw() +
labs(x = "Combined FSIQ Composite Score",
     y = "BRIEF-2 Behavior Regulation T-score",
     size = "Count") +
ggpubr::stat_cor(p.digits = 3) +
scale_x_continuous(breaks = seq(from = 50, to = 150, by = 5)) +
scale_y_continuous(breaks = seq(from = 50, to = 95, by = 5))
```

Figure 14: Relationship Between FSIQ and BRIEF-2 Behavior Regulation
Emotion Regulation

data_clean_main_all %>%
dplyr::filter(complete.cases(asrs_total_t, BRIEF_emot_t)) %>%
ggplot(aes(x = asrs_total_t,
y = BRIEF_emot_t,
  group = 1)) +
  geom_smooth(method = "lm",
  formula = y ~ x,
  color = "red") +
  geom_count() +
  theme_bw() +
  labs(x = "ASRS Total T-score",
y = "BRIEF-2 Emotion Regulation T-score",
size = "Count") +
ggpubr::stat_cor() +
  scale_x_continuous(breaks = seq(from = 50, to = 80, by = 2))+
  scale_y_continuous(breaks = seq(from = 50, to = 95, by = 5))

Figure 15: Relationship Between ASRS Total Score and BRIEF-2 Emotion Regulation
data_clean_main_all %>%
  dplyr::filter(complete.cases(asrs_soccomm_t, BRIEF_emot_t)) %>%
  ggplot(aes(x = asrs_soccomm_t, y = BRIEF_emot_t, group = 1)) +
  geom_smooth(method = "lm", formula = y ~ x, color = "red") +
  geom_count() +
  theme_bw() +
  labs(x = "ASRS Social/Communication T-score", y = "BRIEF-2 Emotion Regulation T-score", size = "Count") +
  ggpubr::stat_cor() +
  scale_x_continuous(breaks = seq(from = 45, to = 85, by = 2)) +
  scale_y_continuous(breaks = seq(from = 45, to = 95, by = 5))

Figure 16: Relationship Between ASRS Social Communication and BRIEF-2 Emotion Regulation
```r
data_clean_main_all %>%
  dplyr::filter(complete.cases(asrs_unbx_t, BRIEF_emot_t)) %>%
  ggplot(aes(x = asrs_unbx_t,
             y = BRIEF_emot_t,
             group = 1)) +
  geom_smooth(method = "lm",
              formula = y ~ x,
              color = "red") +
  geom_count() +
  theme_bw() +
  labs(x = "ASRS Unusual Behavior T-score",
       y = "BRIEF-2 Emotion Regulation T-score",
       size = "Count") +
  ggpubr::stat_cor() +
  scale_x_continuous(breaks = seq(from = 50, to = 80, by = 2))+
  scale_y_continuous(breaks = seq(from = 50, to = 95, by = 5))
```

Figure 17: Relationship Between ASRS Unusual Behavior and BRIEF-2 Emotion Regulation
data_clean_main_all %>%
dplyr::filter(complete.cases(C3P_inatt_t, BRIEF_emot_t)) %>%
ggplot(aes(x = C3P_inatt_t, 
y = BRIEF_emot_t, 
group = 1)) +
  geom_smooth(method = "lm", 
    formula = y ~ x, 
    color = "red") +
  geom_count() +
  theme_bw() +
  labs(x = "Conners 3P Inattention T-score", 
    y = "BRIEF-2 Emotion Regulation T-score", 
    size = "Count") +
  ggrepubr::stat_cor() +
  scale_x_continuous(breaks = seq(from = 35, to = 95, by = 5)) +
  scale_y_continuous(breaks = seq(from = 40, to = 95, by = 5))

$R = 0.39, p = 0.013$

Figure 18: Relationship Between Conners 3P Inattention and BRIEF-2 Emotion Regulation
data_clean_main_all %>%
dplyr::filter(complete.cases(C3P_hyp_t, BRIEF_emot_t)) %>%
ggplot(aes(x = C3P_hyp_t,
        y = BRIEF_emot_t,
        group = 1)) +
geom_smooth(method = "lm",
        formula = y ~ x,
        color = "red") +
geom_count() +
theme_bw() +
labs(x = "Conners 3P Hyperactivity/Impulsivity T-score",
     y = "BRIEF-2 Emotion Regulation T-score",
     size = "Count") +
ggpubr::stat_cor() +
scale_x_continuous(breaks = seq(from = 35, to = 95, by = 5)) +
scale_y_continuous(breaks = seq(from = 40, to = 95, by = 5))

Figure 19: Relationship Between Conners 3P Hyperactivity/Impulsivity and BRIEF-2 Emotion Regulation
```{r}
data_clean_main_all %>%
dplyr::filter(complete_cases(combined_fsiq, BRIEF_emot_t)) %>%
ggplot(aes(x = combined_fsiq,
        y = BRIEF_emot_t,
        group = 1)) +
geom_smooth(method = "lm",
        formula = y ~ x,
        color = "red") +
geom_count() +
theme_bw() +
labs(x = "Combined FSIQ, Composite Score",
    y = "BRIEF-2 Emotion Regulation T-score",
    size = "Count") +
ggpubr::stat_cor(p.digits = 3) +
scale_x_continuous(breaks = seq(from = 50, to = 150, by = 5)) +
scale_y_continuous(breaks = seq(from = 50, to = 90, by = 5))
```

**Figure 20: Relationship Between FSIQ and BRIEF-2 Emotion Regulation**
Cognitive Regulation

data_clean_main_all %>%
dplyr::filter(complete.cases(asrs_total_t, BRIEF_cog_t)) %>%
ggplot(aes(x = asrs_total_t, y = BRIEF_cog_t, group = 1)) +
  geom_smooth(method = "lm", formula = y ~ x, color = "red") +
  geom_count() +
  theme_bw() +
  labs(x = "ASRS Total T-Score", y = "BRIEF-2 Cognitive Regulation T-score", size = "Count") +
  ggpubr::stat_cor() +
  scale_x_continuous(breaks = seq(from = 50, to = 80, by = 5)) +
  scale_y_continuous(breaks = seq(from = 50, to = 80, by = 5))

Figure 21: Relationship Between ASRS Total Score and BRIEF-2 Cognitive Regulation
```r
data_clean_main_all %>%
  dplyr::filter(complete.cases(asrs_soccomm_t, BRIEF_cog_t)) %>%
  ggplot(aes(x = asrs_soccomm_t,
            y = BRIEF_cog_t,
            group = 1)) +
  geom_smooth(method = "lm",
              formula = y ~ x,
              color = "red") +
  geom_count() +
  theme_bw() +
  labs(x = "ASRS Social/Communication T-Score",
       y = "BRIEF-2 Cognitive Regulation T-score",
       size = "Count") +
  ggpubr::stat_cor() +
  scale_x_continuous(breaks = seq(from = 50, to = 80, by = 5)) +
  scale_y_continuous(breaks = seq(from = 50, to = 80, by = 5))
```

Figure 22: Relationship Between ASRS Social Communication and BRIEF-2 Cognitive Regulation
```r
data_clean_main_all %>%
dplyr::filter(complete.cases(asrs_unbx_t, BRIEF_cog_t)) %>%
ggplot(aes(x = asrs_unbx_t, 
y = BRIEF_cog_t, 
group = 1)) +
geom_smooth(method = "lm", 
formula = y ~ x, 
color = "red") +
geom_count() +
theme_bw() +
labs(x = "ASRS Unusual Behavior T-Score", 
y = "BRIEF-2 Cognitive Regulation T-score", 
size = "Count") +
ggpubr::stat_cor() +
scale_x_continuous(breaks = seq(from = 50, to = 80, by = 5)) +
scale_y_continuous(breaks = seq(from = 45, to = 80, by = 5))
```

![Graph showing the relationship between ASRS Unusual Behavior T-Score and BRIEF-2 Cognitive Regulation T-Score.](image)

**Figure 23:** Relationship Between ASRS Unusual Behavior and BRIEF-2 Cognitive Regulation
data_clean_main_all %>%
dplyr::filter(complete.cases(C3P_inatt_t, BRIEF_cog_t)) %>%
ggplot(aes(x = C3P_inatt_t,
y = BRIEF_cog_t,
group = 1)) +
geom_smooth(method = "lm",
formula = y ~ x,
color = "red") +
geom_count() +
theme_bw() +
labs(x = "Conners 3P Inattention T-score",
y = "BRIEF-2 Cognitive Regulation T-score",
size = "Count") +
ggpubr::stat_cor() +
scale_x_continuous(breaks = seq(from = 35, to = 90, by = 5))+
scale_y_continuous(breaks = seq(from = 50, to = 80, by = 5))

Figure 24: Relationship Between Conners 3P Inattention and BRIEF-2 Cognitive Regulation
```r
# Load necessary libraries
library(dplyr)
library(ggplot2)
library(ggpubr)

# Clean the data
data_clean_main_all %>%
  dplyr::filter(complete.cases(C3P_hyp_t, BRIEF_cog_t)) %>%
  ggplot(aes(x = C3P_hyp_t, y = BRIEF_cog_t, group = 1)) +
  geom_smooth(method = "lm", formula = y ~ x, color = "red") +
  geom_count() +
  theme_bw() +
  labs(x = "Conners 3P Hyperactivity/Impulsivity T-score", y = "BRIEF-2 Cognitive Regulation T-score", size = "Count") +
  ggpubr::stat_cor() +
  scale_x_continuous(breaks = seq(from = 35, to = 90, by = 5)) +
  scale_y_continuous(breaks = seq(from = 50, to = 80, by = 5))
```

Figure 25: Relationship Between Conners 3P Hyperactivity/Impulsivity and BRIEF-2 Cognitive Regulation
```r
data_clean_main_all %>%
  dplyr::filter(complete.cases(combined_fsiq, BRIEF_cog_t)) %>%
  ggplot(aes(x = combined_fsiq,
             y = BRIEF_cog_t,
             group = 1)) +
  geom_smooth(method = "lm",
              formula = y ~ x,
              color = "red") +
  geom_count() +
  theme_bw() +
  labs(x = "Combined FSIQ, Composite Score",
       y = "BRIEF-2: Cognitive Regulation (CRI)",
       size = "Count") +
  ggpubr::stat_cor() +
  scale_x_continuous(breaks = seq(from = 55, to = 130, by = 5))+
  scale_y_continuous(breaks = seq(from = 50, to = 80, by = 5))
```

Figure 26: Relationship Between FSIQ and BRIEF-2 Cognitive Regulation
Correlations

BRIEF-2 Indices (DV)

data_clean_main_all %>%
dplyr::select("Behavior\n(BRI)" = BRIEF_bx_t,
          "Emotion\n(ERI)" = BRIEF_emot_t,
          "Cognition\n(CRI)" = BRIEF_cog_t) %>%
cor(use = "pairwise") %>%
corrplot::corrplot.mixed(upper = "ellipse")

![Correlations between BRIEF-2 Domains](image)

Figure 27: Correlations between BRIEF-2 Domains
```r
library(dplyr)
library(corrplot)
data_clean_main_all %>%
dplyr::select("Total" = asrs_total_t,
              "Social/Comm" = asrs_soccomm_t,
              "Unusual Bx" = asrs_unbx_t) %>%
corr(use = "pairwise") %>%
corrplot::corrplot.mixed(upper = "ellipse")
```

Figure 28: Correlations between ASRS Domains
Conners 3P

data_clean_main_all %>%
dplyr::select("Inattention" = C3P_inatt_t,
"Hyp/Impul" = C3P_hyp_t) %>%
cor(use = "pairwise") %>%
corrplot::corrplot.mixed(upper = "ellipse")

Figure 29: Correlations Between Conners 3P Domains
DV and IV

data_clean_main_all %>%
dplyr::select("BRI" = BRIEF_bx_t,
               "ERI" = BRIEF_emot_t,
               "CRI" = BRIEF_cog_t,
               "Atot" = asrs_total_t,
               "Soc" = asrs_soccomm_t,
               "UnBx" = asrs_unbx_t,
               "Inatt" = C3P_inatt_t,
               "Hyp" = C3P_hyp_t,
               "FSIQ" = combined_fsiq) %>%
cor(use = "pairwise") %>%
corrplot::corrplot.mixed(upper = "ellipse")

<table>
<thead>
<tr>
<th></th>
<th>BRI</th>
<th>ERI</th>
<th>CRI</th>
<th>Atot</th>
<th>Soc</th>
<th>UnBx</th>
<th>Inatt</th>
<th>Hyp</th>
<th>FSIQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRI</td>
<td>1</td>
<td>0.52</td>
<td>0.67</td>
<td>0.63</td>
<td>0.44</td>
<td>0.47</td>
<td>0.51</td>
<td>0.69</td>
<td>0.30</td>
</tr>
<tr>
<td>ERI</td>
<td>0.52</td>
<td>1</td>
<td>0.30</td>
<td>0.51</td>
<td>0.49</td>
<td>0.48</td>
<td>0.54</td>
<td>0.47</td>
<td>0.38</td>
</tr>
<tr>
<td>CRI</td>
<td>0.67</td>
<td>0.30</td>
<td>1</td>
<td>0.59</td>
<td>0.75</td>
<td>0.71</td>
<td>0.42</td>
<td>0.47</td>
<td>0.66</td>
</tr>
<tr>
<td>Atot</td>
<td>0.63</td>
<td>0.51</td>
<td>0.59</td>
<td>1</td>
<td>0.75</td>
<td>0.04</td>
<td>0.30</td>
<td>0.22</td>
<td>0.39</td>
</tr>
<tr>
<td>Soc</td>
<td>0.44</td>
<td>0.49</td>
<td>0.75</td>
<td>0.75</td>
<td>1</td>
<td>0.49</td>
<td>0.04</td>
<td>0.24</td>
<td>0.22</td>
</tr>
<tr>
<td>UnBx</td>
<td>0.47</td>
<td>0.22</td>
<td>0.71</td>
<td>0.71</td>
<td>0.48</td>
<td>1</td>
<td>-0.02</td>
<td>0.12</td>
<td>0.20</td>
</tr>
<tr>
<td>Inatt</td>
<td>0.51</td>
<td>0.39</td>
<td>0.66</td>
<td>0.47</td>
<td>0.25</td>
<td>0.22</td>
<td>1</td>
<td>0.54</td>
<td>0.20</td>
</tr>
<tr>
<td>Hyp</td>
<td>0.69</td>
<td>0.47</td>
<td>0.54</td>
<td>0.38</td>
<td>0.12</td>
<td>0.22</td>
<td>0.54</td>
<td>1</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Figure 30: Correlations Between All Measure Domains/
Complete Case Multilevel Analysis

Person-Profile Plot

data_long %>%
ggplot(aes(x = domain,
        y = brief,
        group = ID)) +

geom_point() +
geom_line() +
theme_bw() +
labs(x = NULL,
     y = "Observed Values of Executive Functioning T-Score")

Figure 31: Person-Profile Plot: Observed Executive Functioning in the Three Domains
Null Model

Fit Model

```r
fit_0_re <- lmerTest::lmer(brief ~ domain + (1|ID),
                          data = data_comp,
                          REML = TRUE)

performance::icc(fit_0_re)

# Intraclass Correlation Coefficient

Adjusted ICC: 0.500
Conditional ICC: 0.402
```
Model A

Fit Model

```r
fit_a_re <- lmerTest::lmer(brief ~ domain + I((C3P_hyp_t-50)/10) + I((asrs_soccomm_t-50)/10) + I((C3P_inatt_t-50)/10) + I((asrs_unbx_t-50)/10) + I(combined_fsiq - 100) + covid_onset + child_sex + child_age_yrs + (1|ID), data = data_comp,
REML = TRUE)
```

Parameter Estimates

```r
summary(fit_a_re)
```

Linear mixed model fit by REML. t-tests use Satterthwaite's method [ lmerModLmerTest]
Formula: brief ~ domain + I((C3P_hyp_t - 50)/10) + I((asrs_soccomm_t - 50)/10) + I((C3P_inatt_t - 50)/10) + I((asrs_unbx_t - 50)/10) + I(combined_fsiq - 100) + covid_onset + child_sex + child_age_yrs + (1 | ID)
Data: data_comp

REML criterion at convergence: 653.5

Scaled residuals:

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>1Q</th>
<th>Median</th>
<th>3Q</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-2.09204</td>
<td>-0.71250</td>
<td>0.05854</td>
<td>0.64821</td>
<td>1.98666</td>
</tr>
</tbody>
</table>

Random effects:

<table>
<thead>
<tr>
<th>Groups</th>
<th>Name</th>
<th>Variance</th>
<th>Std.Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>(Intercept)</td>
<td>7.45</td>
<td>2.729</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>39.37</td>
<td>6.274</td>
</tr>
</tbody>
</table>

Number of obs: 102, groups: ID, 34

Fixed effects:

|                 | Estimate | Std. Error | df   | t value | Pr(>|t|) |
|-----------------|----------|------------|------|---------|----------|
| (Intercept)     | 46.317477| 5.033448   | 26.585964 | 9.202 | 9.46e-10 *** |
| domainEmotion   | 5.852941 | 1.521743   | 66.000000 | 3.846 | 0.000273 *** |
| domainCognitive | -4.823529| 1.521743   | 66.000000 | -3.170 | 0.002314 ** |
| I((C3P_hyp_t - 50)/10) | 2.945955 | 1.019582 | 25.000000 | 2.889 | 0.007864 ** |
| I((asrs_soccomm_t - 50)/10) | 3.138028 | 1.288214 | 25.000000 | 2.436 | 0.022317 * |
| I((C3P_inatt_t - 50)/10) | 0.451252 | 1.288214 | 25.000000 | 0.643683 |
| I((asrs_unbx_t - 50)/10) | 1.964824 | 1.653894 | 25.000000 | 1.188 | 0.245998 |
| I(combined_fsiq - 100) | 0.006186 | 0.046543 | 25.000000 | 0.133 | 0.895324 |
covid_onsetpre  2.397723  1.601311  25.000000  1.497  0.146823
child_sexMale  1.499251  2.326988  25.000000  0.644  0.525256
child_age_yrs  0.403817  0.292339  25.000000  1.381  0.179399

---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:

<table>
<thead>
<tr>
<th></th>
<th>(Intr)</th>
<th>dmnEmotn</th>
<th>dmnCgn</th>
<th>I((C3P_h_-50)/10)</th>
<th>I((srs_s_-50)/10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>domainEmotn</td>
<td>-0.151</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>domainCgnv</td>
<td>-0.151</td>
<td>0.500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I((C3P_h_-50)/10)</td>
<td>-0.182</td>
<td>0.000</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I((srs_s_-50)/10)</td>
<td>-0.150</td>
<td>0.000</td>
<td>0.000</td>
<td>0.203</td>
<td></td>
</tr>
<tr>
<td>I((C3P_n_-50)/10)</td>
<td>0.010</td>
<td>0.000</td>
<td>0.000</td>
<td>-0.764</td>
<td>-0.341</td>
</tr>
<tr>
<td>I((srs_n_-50)/10)</td>
<td>-0.417</td>
<td>0.000</td>
<td>0.000</td>
<td>-0.271</td>
<td>-0.271</td>
</tr>
<tr>
<td>I(cmb_-100)</td>
<td>-0.349</td>
<td>0.000</td>
<td>0.000</td>
<td>0.021</td>
<td>0.245</td>
</tr>
<tr>
<td>covid_nstpr</td>
<td>-0.196</td>
<td>0.000</td>
<td>0.000</td>
<td>0.068</td>
<td>0.090</td>
</tr>
<tr>
<td>child_sexMl</td>
<td>-0.544</td>
<td>0.000</td>
<td>0.000</td>
<td>0.186</td>
<td>0.139</td>
</tr>
<tr>
<td>child_g_yrs</td>
<td>-0.499</td>
<td>0.000</td>
<td>0.000</td>
<td>-0.059</td>
<td>-0.214</td>
</tr>
<tr>
<td>I((C3P_n_-50)/10)</td>
<td>I((srs_n_-50)/10)</td>
<td>I(_-10 cvd_ns chld_M</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Effect Size

performance::r2(fit_a_re)

# R2 for Mixed Models

Conditional R2: 0.615
Marginal R2: 0.542
Model B

Fit Model

```
fit_b_re <- lmerTest::lmer(brief ~ domain + I((C3P_hyp_t - 50)/10)+
I((asrs_soccomm_t - 50)/10) + (1
   data = data_comp,
   REML = TRUE)
```

Parameter Estimates

```
summary(fit_b_re)
```

Linear mixed model fit by REML. t-tests use Satterthwaite's method [ lmerModLmerTest]
Formula: brief ~ domain + I((C3P_hyp_t - 50)/10) + I((asrs_soccomm_t -
   50)/10) + (1 | ID)
   Data: data_comp

REML criterion at convergence: 665.3

Scaled residuals:
  Min 1Q Median 3Q Max
-2.3591 -0.7817 0.1038 0.7482 1.8855

Random effects:
  Groups   Name        Variance Std.Dev.
  ID       (Intercept) 7.545   2.7476
  Residual            39.367  6.2738
  Number of obs: 102, groups: ID, 34

Fixed effects:
  Estimate Std. Error df t value Pr(>|t|)
  (Intercept)    55.2372   2.4281 40.6106 22.749 < 2e-16 ***
  domainEmotion  5.8529    1.5217 66.0000  3.846  0.000273 ***
  domainCognitive-4.8235   1.5217 66.0000 -3.170   0.002314 **
  I((C3P_hyp_t - 50)/10) 3.3820   0.6246 31.0000  5.415    6.53e-06 ***
  I((asrs_soccomm_t - 50)/10) 3.8463  1.0863 31.0000  3.541    0.001284 **
  ---
  Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
   (Intr)   dmnEmotn dmnCgn  I((-C5
domainEmotn -0.313
domainCgn -0.313  0.500
```
I((C3P_-50) -0.529 0.000 0.000
I((_-50)/1 -0.563 0.000 0.000 -0.220

Effect Size

performance::r2(fit_b_re)

# R2 for Mixed Models

Conditional R2: 0.601
Marginal R2: 0.524
Follow-up Pairwise Tests

```r
totalSD <- lme4::VarCorr(fit_b_re) %>%
data.frame() %>%
dplyr::summarise(tot_var = sum(vcov)) %>%
dplyr::pull(tot_var) %>%
sqrt()

totalSD

[1] 6.849255

fit_b_re %>%
  emmeans::emmeans(pairwise ~ domain,
  at = list(C3P_hyp_t = 76.57,
            asrs_soccomm_t = 65.32),
  adjust = "none")

$emmeans
domain  emmean   SE  df lower.CL upper.CL
Behavior  70.1  1.18 90.7   67.8    72.5
Emotion   76.0  1.18 90.7   73.6    78.3
Cognitive 65.3  1.18 90.7   63.0    67.6

Degrees-of-freedom method: kenward-roger
Confidence level used: 0.95

$contrasts
  contrast   estimate   SE  df t.ratio p.value
Behavior - Emotion  -5.85  1.52  66 -3.846  0.0003
Behavior - Cognitive  4.82  1.52  66  3.170  0.0023
Emotion - Cognitive   10.68 1.52  66  7.016 <.0001

Degrees-of-freedom method: kenward-roger
```
Compare Model A vs. B

```r
performance::compare_performance(fit_a_re, fit_b_re)
```

# Comparison of Model Performance Indices

<table>
<thead>
<tr>
<th>Name</th>
<th>Model</th>
<th>AIC</th>
<th>AIC weights</th>
<th>AICc</th>
<th>AICc weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>fit_a_re</td>
<td>lmerModLmerTest</td>
<td>693.750</td>
<td>0.065</td>
<td>697.886</td>
<td></td>
</tr>
<tr>
<td>fit_b_re</td>
<td>lmerModLmerTest</td>
<td>688.420</td>
<td>0.935</td>
<td>689.611</td>
<td></td>
</tr>
</tbody>
</table>

```r
anova(fit_a_re, fit_b_re)
```

Data: data_comp

Models:
fit_b_re: brief ~ domain + I((C3P_hyp_t - 50)/10) + I((asrs_soccomm_t - 50)/10) + (1 | ID)
fit_a_re: brief ~ domain + I((C3P_hyp_t - 50)/10) + I((asrs_soccomm_t - 50)/10) + I((C3P_inatt_t - 50)/10) + I((C3P_inatt_t - 50)/10)

<table>
<thead>
<tr>
<th>npar</th>
<th>AIC</th>
<th>BIC</th>
<th>logLik</th>
<th>deviance</th>
<th>Chisq</th>
<th>Df</th>
<th>Pr(&gt;Chisq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>fit_b_re</td>
<td>7</td>
<td>688.38</td>
<td>706.75</td>
<td>-337.19</td>
<td>674.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fit_a_re</td>
<td>13</td>
<td>692.91</td>
<td>727.03</td>
<td>-333.45</td>
<td>666.91</td>
<td>7.4708</td>
<td>6</td>
</tr>
</tbody>
</table>
texreg::knitreg(list("Model A" = fit_a_re,  
   "Model B" = fit_b_re),  
   single.row = TRUE,  
   caption = "MLM Model Comparison: Model A vs. Model B",  
   caption.above = TRUE,  
   float.pos = "hb")

Table 4: MLM Model Comparision: Model A vs. Model B

<table>
<thead>
<tr>
<th></th>
<th>Model A</th>
<th>Model B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>46.32 (5.03)**</td>
<td>55.24 (2.43)**</td>
</tr>
<tr>
<td>domainEmotion</td>
<td>5.85 (1.52)**</td>
<td>5.85 (1.52)**</td>
</tr>
<tr>
<td>domainCognitive</td>
<td>-4.82 (1.52)**</td>
<td>-4.82 (1.52)**</td>
</tr>
<tr>
<td>(C3P_hyp_t - 50)/10</td>
<td>2.95 (1.02)**</td>
<td>3.38 (0.62)**</td>
</tr>
<tr>
<td>(asrs_soccomm_t - 50)/10</td>
<td>3.14 (1.29)*</td>
<td>3.85 (1.09)**</td>
</tr>
<tr>
<td>(C3P_inatt_t - 50)/10</td>
<td>0.45 (0.96)</td>
<td></td>
</tr>
<tr>
<td>(asrs_unbx_t - 50)/10</td>
<td>1.96 (1.65)</td>
<td></td>
</tr>
<tr>
<td>combined_fsiq - 100</td>
<td>0.01 (0.05)</td>
<td></td>
</tr>
<tr>
<td>covid_onsetpre</td>
<td>2.40 (1.60)</td>
<td></td>
</tr>
<tr>
<td>child_sexMale</td>
<td>1.50 (2.33)</td>
<td></td>
</tr>
<tr>
<td>child_age_yrs</td>
<td>0.40 (0.29)</td>
<td></td>
</tr>
<tr>
<td>AIC</td>
<td>679.45</td>
<td>679.29</td>
</tr>
<tr>
<td>BIC</td>
<td>713.58</td>
<td>697.66</td>
</tr>
<tr>
<td>Log Likelihood</td>
<td>-326.73</td>
<td>-332.64</td>
</tr>
<tr>
<td>Num. obs.</td>
<td>102</td>
<td>102</td>
</tr>
<tr>
<td>Num. groups: ID</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Var: ID (Intercept)</td>
<td>7.45</td>
<td>7.55</td>
</tr>
<tr>
<td>Var: Residual</td>
<td>39.37</td>
<td>39.37</td>
</tr>
</tbody>
</table>

**p < 0.001; ***p < 0.01; *p < 0.05
Multiple Imputation Analysis

Number of imputed datasets

```r
m <- length(implist)
m
[1] 500
```

Fit the Model

```r
fit_mlm_basic <- data.frame(imp_num = 1:m) %>%
dplyr::mutate(code = glue::glue("lme4::lmer(brief ~ domain +
  I((C3P_hyp_t-50)/10) +
  I((asrs_soccomm_t-50)/10) + (1|ID),
  data = implist[[imp_num]],
  control = lmerControl(check.conv.singular = .makeCC(action = 'ignore',
  tol = 1e-4)))") %>%
dplyr::mutate(fit = purrr::map(code, function(x)
  eval(parse(text = x)))) %>%
dplyr::mutate(sing = purrr::map_lgl(fit, lme4::isSingular)) %>%
dplyr::mutate(est3var = purrr::map(faption(x) {
  emmeans::emmeans(object = x,
  specs = ~
  domain*C3P_hyp_t*
  asrs_soccomm_at =
  list(C3P_hyp_t =
  c(65, 75, 85),
  domain, at =
  list(C3P_hyp_t =
  76.57,
  ))) %>%
dplyr::mutate(est1var = purrr::map(fit, 
  function(x) {
  emmeans::emmeans(object = x,
  specs = ~ domain, 
  at =
  list(C3P_hyp_t =
  76.57,
  ))) %>%
dplyr::mutate(pairs1var = purrr::map(est1var, 
  function(x) {
  pairs(x, adjust = "none")
  })) %>%
dplyr::mutate(df_est3var = purrr::map(est3var, data.frame)) %>%
dplyr::mutate(df_est1var = purrr::map(est1var, data.frame)) %>%
dplyr::mutate(df_pairs1var = purrr::map(pairs1var, data.frame)) %>%
dplyr::mutate(code_null = glue::glue("lme4::lmer(brief ~ 1 + (1|ID),
  data = implist[[imp_num]],
  control = lmerControl
  (check.conv.singular = .makeCC(action
```
Identify any data sets for which the MLM was singular (n = 7)

```r
imp_sing <- fit_mlm_basic %>%
  dplyr::filter(sing == TRUE) %>%
  dplyr::pull(imp_num)
imp_sing

[1]  34 140 143 319 337 339 430

imp_sing_null <- fit_mlm_basic %>%
  dplyr::filter(sing_null == TRUE) %>%
  dplyr::pull(imp_num)
imp_sing_null

integer(0)
```
Pooled Parameter Estimates

```r
fit_mlm_basic_pool <- fit_mlm_basic %>%
dplyr::filter(sing == FALSE) %>%
dplyr::pull(fit) %>%
mitml::testEstimates(extra.pars = TRUE)
```

```
Call:
mitml::testEstimates(model = ., extra.pars = TRUE)

Final parameter estimates and inferences obtained from 493 imputed data sets.

|                         | Estimate | Std.Error | t.value | df   | P(>|t|) |
|-------------------------|----------|-----------|---------|------|---------|
| (Intercept)             | 57.521   | 3.003     | 19.153  | 2657.022 | 0.000   |
| domaincog_t             | -2.956   | 1.756     | -1.684  | 2109.628 | 0.092   |
| domainemot_t            | 6.024    | 1.887     | 3.192   | 1612.261 | 0.001   |
| I((C3P_hyp_t - 50)/10)  | 3.205    | 0.729     | 4.399   | 3592.289 | 0.000   |
| I((asrs_soccomm_t - 50)/10) | 2.263 | 1.223     | 1.851   | 2034.789 | 0.064   |

Unadjusted hypothesis test as appropriate in larger samples.
Conditional ICC

```
fit_mlm_basic_pool$extra.pars %>%
data.frame() %>%
dplyr::rename(Var = Estimate) %>%
tibble::rownames_to_column() %>%
dplyr::mutate(SD = ifelse(!stringr::str_detect(rowname, "ICC"),
               sqrt(Var), NA))
```

<table>
<thead>
<tr>
<th>rowname</th>
<th>Var</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept~Intercept</td>
<td>12.3728069</td>
<td>3.517500</td>
</tr>
<tr>
<td>Residual~Residual</td>
<td>51.8190285</td>
<td>7.198544</td>
</tr>
<tr>
<td>ICC</td>
<td>ID</td>
<td>0.1890028</td>
</tr>
</tbody>
</table>
Effect Size: Variance Explained

```
fit_mlm_basic %>%
dplyr::filter(sing == FALSE) %>%
dplyr::pull(fit) %>%
iml::multilevelR2()
```

<table>
<thead>
<tr>
<th></th>
<th>RB1</th>
<th>RB2</th>
<th>SB</th>
<th>MVP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.2861489</td>
<td>0.4861788</td>
<td>0.3312870</td>
<td>0.3405607</td>
</tr>
</tbody>
</table>
Estimated Marginal Means (Pooled over MI)

```r
pool_emmean_domain <- fit_mlm_basic %>%
dplyr::filter(sing == FALSE) %>%  # remove singular models from list
tidyr::unnest(cols = df_estivar) %>%
dplyr::select(names(fit_mlm_basic$df_estivar[[1]])) %>%
to_dplyr::mutate(domain = domain %>%
  forcats::fct_relevel("emot_t", after = 1) %>%
  forcats::fct_recode("Behavior\n(BRI)" = "bx_t",
  "Emotion\n(ERI)" = "emot_t",
  "Cognition\n(CRI)" = "cog_t")) %>%
dplyr::group_by(domain) %>%
dplyr::summarise_at(vars(emmean, SE,lower.CL, upper.CL),
mean)
```

```r
pool_emmean_domain %>%
pander::pander(caption = "Pooled Estimated Marginal Means of Each Domain From the Multilevel Model"
```

<table>
<thead>
<tr>
<th>domain</th>
<th>emmean</th>
<th>SE</th>
<th>lower.CL</th>
<th>upper.CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavior (BRI)</td>
<td>69.5</td>
<td>0.9965</td>
<td>67.54</td>
<td>71.47</td>
</tr>
<tr>
<td>Emotion (ERI)</td>
<td>75.53</td>
<td>0.9965</td>
<td>73.56</td>
<td>77.5</td>
</tr>
<tr>
<td>Cognition (CRI)</td>
<td>66.55</td>
<td>0.9965</td>
<td>64.58</td>
<td>68.51</td>
</tr>
</tbody>
</table>

Table 5: Pooled Estimated Marginal Means of Each Domain From the Multilevel Model Fit on the Multiply Imputed Data
Effect Size: Standardized Mean Differences (SMD)

\[
SD_{pooled} \leftarrow \text{fit_mlm_basic_pool}$extra.pars \%>%
  \text{data.frame()} \%>%
  \text{tibble::rownames_to_column()} \%>%
  \text{dplyr::filter(!stringr::str_detect(rownames, "ICC")) \%>%
  \text{dplyr::pull(Estimate) \%>%
  \text{sum()} \%>%
  \text{sqrt()}
\]

SD_{pooled}

[1] 8.011981

df_bracket \leftarrow \text{pool_emmean_domain \%>%
  \text{dplyr::select(group1 = domain, emmean1 = emmean) \%>%
  \text{dplyr::mutate(group2 = $group1[c(2, 3, 1)]) \%>%
  \text{dplyr::mutate(emmean2 = $emmean1[c(2, 3, 1)]) \%>%
  \text{dplyr::mutate(b = abs(emmean1 - emmean2)) \%>%
  \text{dplyr::mutate(SMD = b/SD_pooled) \%>%
  \text{dplyr::mutate_at(vars(b, SMD),
       round,
       2) \%>%
  \text{dplyr::mutate(p.val = c("= .001***", "< .001***", ", = .934"))
\]

df_bracket

dplyr::select(-emmean1, -emmean2) \%>%
pander::pander(caption = "Pairwise Comparisons of Estimated Marginal Means of Each Domain From the Multilevel Model Fit on the Multiply Imputed Data"

<table>
<thead>
<tr>
<th>group1</th>
<th>group2</th>
<th>b</th>
<th>SMD</th>
<th>p.val</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavior (BRI)</td>
<td>Emotion (ERI)</td>
<td>6.02</td>
<td>0.75</td>
<td>= .001***</td>
</tr>
<tr>
<td>Emotion (ERI)</td>
<td>Cognition (CRI)</td>
<td>8.98</td>
<td>1.12</td>
<td>&lt; .001***</td>
</tr>
<tr>
<td>Cognition (CRI)</td>
<td>Behavior (BRI)</td>
<td>2.96</td>
<td>0.37</td>
<td>= .934</td>
</tr>
</tbody>
</table>
Visualize the Model

Figure 3

```r
fit_mlm_basic %>%
dplyr::filter(sing == FALSE) %>% # remove singular models from list
tidyr::unnest(cols = df_est3var[[1]]) %>%
dplyr::select(names(fit_mlm_basic$df_est3var[[1]])) %>%
dplyr::mutate(domain = domain %>%
    forcats::fct_recode("Behavior (BRI)" = "bx_t",
                       "Cognition (CRI)" = "cog_t",
                       "Emotion (ERI)" = "emot_t")) %>%
dplyr::mutate(C3P_hyp_t = factor(C3P_hyp_t,
                                levels = c(65, 75, 85),
                                labels = c("Low (65)",
                                           "Medium (75)",
                                           "High (85)"))) %>%
dplyr::mutate(asrs_soccomm_t = factor(asrs_soccomm_t,
                                        levels = c(55, 65, 75),
                                        labels = c("Low (55)",
                                                   "Medium (65)",
                                                   "High (75)"))) %>%
dplyr::group_by(domain, C3P_hyp_t, asrs_soccomm_t) %>%
dplyr::summarise_at(vars(emmean, SE, df, lower.CL, upper.CL),
                     mean) %>%
dplyr::ungroup() %>%
ggplot(aes(group = C3P_hyp_t,
           y = emmean,
           x = asrs_soccomm_t)) +
    ymin = emmean + SE_ribbon(aes(ymax = emmean + SE,
                                  fill = C3P_hyp_t),
                               alpha = .2,
                               width = .25) +
geom_line(aes(linetype = C3P_hyp_t)) +
theme_bw() +
facet_grid(~ domain) +
labs(linetype = "Hyperactivity/Impulsivity",
     fill = "Hyperactivity/Impulsivity",
     y = "Pooled Estimated Marginal Mean",
     x = "Social Communication") +
theme(legend.position = "bottom") +
scale_fill_grey() +
scale_color_grey()
```
Figure 4

```r
fit_mlm_basic %>%
  dplyr::filter(sing == FALSE) %>% # remove singular models from list
tidyr::unnest(cols = df_estivar) %>%
dplyr::select(names(fit_mlm_basic$df_estivar[[1]])) %>%
dplyr::mutate(domain = domain %>%
  forcats::fct_relevel("emot_t", after = 1) %>%
  forcats::fct_recode("Behavior\n(BRI)" = "bx_t",
    "Emotion\n(ERI)" = "emot_t",
    "Cognition\n(CRI)" = "cog_t") %>%
dplyr::group_by(domain) %>%
dplyr::summarise_at(vars(emmean, SE, df, lower.CL, upper.CL),
  mean) %>%
dplyr::ungroup() %>%
ggplot(aes(x = domain,
    y = emmean,
    group = 1)) +
  geom_point(size = 3) +
  geom_line() +
  geom_errorbar(aes(ymin = lower.CL,
    ymax = upper.CL),
    width = .25) +
  theme_bw() +
  labs(x = NULL,
    y = "Pooled Estimated Marginal Mean \nExecutive Functioning T-Score") +
  stat_pvalue_manual(data = df_bracket,
    label = "SMD = {SMD}, p {p.val}";
    y.position = 79.5,
    step.increase = 0.08) +
  scale_y_continuous(expand = expansion(mult = c(.08, .08)))
```
Behavior (BRI)  
Emotion (ERI)  
Cognition (CRI)
VITAE
Curriculum Vitae
Kandice J. Benallie

Education

August 2023

**Doctor of Philosophy in Psychology**
Emphasis: School Psychology
Utah State University, Logan, Utah
Dissertation: *Executive Functioning in Children with ASD and Co-Occurring Neurodevelopmental Disorders*
Chair: Maryellen McClain Verdoes, Ph.D.

December 2019

**Master of Science**
Emphasis: School Psychology
Utah State University, Logan, Utah
Thesis: *Parent Knowledge of Autism Spectrum Disorder*
Chair: Gretchen G. Peacock, Ph.D.

May 2017

**Bachelor of Science**
Utah State University, Logan, Utah
Major: Psychology, with Honors
Minor: Family and Human Development
Honors Thesis: *Increasing Parenting Knowledge: A Pilot Study*
Honors Chair: Gretchen G. Peacock, Ph.D.

Doctoral Internship (APA-Accredited)
Johns Hopkins All Children’s Hospital
**Psychology Doctoral Intern**
**Major Rotations: Autism/Neurodevelopmental Disorders and Consultation/Liaison**
Saint Petersburg, Florida
August 2022 – Current

Clinical Practicum Experience
Intermountain Healthcare McKay-Dee Behavioral Health Clinic
**Psychology Graduate Clinician**
Ogden, UT
September 2021 – May 2022
**Supervisor: Bryan Bushman, Ph.D.**
Description: Conducted comprehensive evaluations and provided behavioral and psychological therapy services in an outpatient medical clinic. Evaluated children and adolescents for various neurodevelopmental, psychological, and neuropsychological conditions – e.g., autism, ADHD, traumatic brain injury, and fetal alcohol syndrome. Used parent training, cognitive-behavioral therapy, and dialectical behavior therapy strategies to treat children and adolescents for emotional and behavioral difficulties.

USU SCCE Integrated Assessment Clinic
**Psychology Graduate Clinician**
Logan, UT
August 2019 – August 2020; December 2020 – July 2021
**Supervisor: Maryellen McClain Verdoes, Ph.D.**
Description: Worked in an integrated team setting evaluating children for neurodevelopmental, behavioral, emotional, and elimination concerns. Administered and interpreted numerous intellectual/cognitive, academic, behavioral, observational, and emotional assessments. Presented evaluation results to the evaluation team, wrote comprehensive evaluation reports, as well as led feedback sessions with families.

Cache County School District
Logan, UT
March 2020
**Supervisor: Joe Cottrell, EdS**
Description: Assessed middle school students for special education eligibility using cognitive/intellectual, behavioral, academic, and language assessments under a Patterns of Strengths and Weaknesses model.

**Up to 3 Early Intervention Program**  
**Behavior Specialist**  
Logan, UT  
May 2020 – May 2021  
*Supervisor: Gretchen G. Peacock, Ph.D.*

Description: Provided in-home behavior management and parent training services to families with children under the age of 3 years who qualify for early intervention services. Collaborated with other professionals (e.g., speech-language pathologist, occupational therapist, nutritionist, autism specialist) to provide optimal services to families. Attended and presented evaluation results at IFSP meetings.

**USU SCCE Behavioral Health Clinic**  
**Parent Training/Behavior Management Therapist**  
Logan, UT  
August 2019 – May 2020  
*Supervisor: Clint Field, Ph.D.*

Description: Provided parent training/behavior management techniques in a clinical environment with parents of children 12 years and younger. Worked with children with oppositional defiant, adjustment, and elimination behavior problems.

**USU Autism Support Services: Education, Research, and Training (ASSERT) Program**  
Logan, UT  
April 2019 – December 2019  
*Supervisor: Thomas S. Higbee, Ph.D., BCBA-D, LBA*

Description: Worked with preschool-aged children with autism and implemented applied behavior analysis (ABA) interventions in individual and group settings (e.g., behavior modification).

**Preston School District**  
Preston, ID  
August 2018 – May 2019  
*Supervisor: Janell Royle, EdS*

Description: Administered cognitive assessments (i.e., WISC-V), performed classroom observations, prepared and scored behavioral and social-emotional rating scales, interpreted and presented evaluation results at an IEP meeting, attended IEP meetings, consulted with teachers to implement behavior intervention plans, and led a weekly friendship group.

**Graduate-Level Fellowships**  
**Utah Regional Leadership Education in Neurodevelopmental Disabilities (URLEND) – Autism Enhanced (AE) Trainee**  
Logan, UT  
Fall 2020 – Spring 2021  
Description: Completed 150 hours over the 2020-2021 school year, divided evenly between clinical, research, and leadership experiences focused on children with autism spectrum disorder. These experiences included seminars focused on best practices in working with children with autism spectrum disorder and their families, interdisciplinary service provision, and a research project with an interdisciplinary group focused on autism spectrum disorder.

**Utah Regional Leadership Education in Neurodevelopmental Disabilities (URLEND) – Long-term Trainee**  
Logan, UT  
August 2019 – May 2020  
Description: Completed 300 hours over the 2019-2020 school year, divided evenly between clinical, research, and leadership experiences focused on children with neurodevelopmental disabilities. Some of these experiences included weekly 3.5-hour didactic seminars...
about topics related to children with neurodevelopmental disabilities, being matched with a local family, interdisciplinary service provision, and completing a year-long leadership project with other trainees.

**Supervision Experiences**

**USU SCCE Behavioral Health Clinic**
Logan, UT  
November 2021 – April 2022  
*Supervisor: Maryellen McClain Verdoes, Ph.D.*

Description: Supervised other graduate students completing child psychological evaluations under the supervision of a licensed psychologist.

**Autism and Neurodevelopmental Disorders (AND) Lab**
Logan, UT  

Description: Supervised graduate students completing child psychological evaluations under the supervision of a licensed psychologist.

**Research Experiences**

**Autism and Neurodevelopmental Disorders (AND) Lab Graduate Student Researcher**
Logan, UT  
*Director: Maryellen McClain Verdoes, Ph.D.*

Description: Involved in several research projects with varied responsibilities (e.g., administering assessments, locating, and organizing research articles, data collection, data entry and analysis, and manuscript writing). Assisted with overall Autism and Neurodevelopmental Disorders Lab organizational activities (e.g., scheduling research participants, sending announcements to lab members, operating the lab calendar, and RA training).

**Teaching Experience**

**Teaching Assistant – Utah State University**
Logan, UT  
PSY 3500 – Research Methods: Spring 2022  
PSY 3010 – Psychological Statistics: Fall 2017, Summer 2018, Spring 2020, Fall 2021  
PSY 3720 – Behavior Assessment and Intervention I: Fall 2019  
PSY 4230 – Psychology of Gender: Fall 2018  
PSY 4950 – Undergraduate Apprenticeship: Fall 2017, Summer 2018, Spring 2022

**Publications**


Accepted/In Press

In Review


Presentations

Paper Presentations

National


Poster Presentations

International
Benallie, K. J., Golson, M., McClain, M. B., and Harris, B. (May 2019). Current state of ASD knowledge in
the general population. Poster presented at International Society of Autism Research (INSAR) Annual Convention, Montreal, Canada.

National


Regional
Olson, K., Benney, C., McClain, M., Peacock, G., Harris, B. (April 2018). Autism Spectrum Knowledge Scale (ASKS) for the general population. Poster presented at Rocky Mountain Psychological Association (RMPA) Annual Convention, Denver, CO.


Local

Peer Reviewer
Journal of Autism and Developmental Disorders, article review with Dr. Maryellen McClain Verdoes: Fall 2020, Spring 2021
Applied Neuropsychology: Child, article review with Dr. Maryellen McClain Verdoes: Summer 2020
Psychology in the Schools, article review with Dr. Maryellen McClain Verdoes: Spring 2018, Fall 2018, Summer 2019, Fall 2019
NASP presentations, presentation proposal review with Dr. Maryellen McClain Verdoes, Summer 2018

Leadership Experiences
USU Student Affiliates of School Psychologists (SASP) - Professional Development Chair
Logan, UT
August 2019 – May 2020
Description: Led the SASP Professional Development Committee. This involves planning 1-2 activities each semester that provide professional development experience to current students.

USU Honors Alumni Mentoring Program
Logan, UT
August 2018 – May 2019
Description: At the beginning of the year, I was matched with a current USU honors program student. I meet with them monthly to discuss topics related to the honors program requirements, applying for graduate school, and other professional development-related topics (e.g., CVs, interviews).

USU Student Affiliates of School Psychologists (SASP) - President
Logan, UT
April 2018 – May 2019
Description: Created a USU chapter of SASP. Responsibilities included organizing and supporting service, awareness and promotion, professional development, and events committees. The goals of SASP are to promote professional education and training within the field of school psychology, service in the community, awareness of the field of school psychology and the program at USU, and professional development.

USU National Association of School Psychology (NASP) Student Leader
Logan, UT
April 2018 – May 2019
Description: Acted as a liaison between the NASP student committee and the school psychology graduate students at USU. Communicated necessary information to graduate students and faculty regarding NASP.

Certifications and Exams
Praxis Exam for School Psychologists
Passed: September 2020

Professional Development and Trainings
TEACCH Autism Program Training
TEACCH Autism Program
April 2021
Description: Attended a two-week training that taught education professionals strategies used in the TEACCH Autism Program.

Childhood Autism Rating Scale, Second Edition (CARS-2) – Virtual Training
TEACCH Autism Program
October 2020
Description: Attended a two-day training that discussed each code from both the CARS-2 standard and high-functioning versions, discussed two respective cases, and completed reliability coding.

ADOS-2 Workshop – Toddler Module
Utah State University
July 2019
ADOS-2 Independent Trainer: Courtney Burnette, PhD
Description: Attended a one-day training to learn how to administer and interpret the ADOS-2 toddler module.

Grant Writing Seminar
Utah State University
September 2018
Description: Attended a one-day training about grant writing.

ADOS-2 Introductory/Clinical Workshop
Brigham Young University
August 2018
ADOS-2 Independent Trainer: Courtney Burnette, PhD
Description: Attended a three-day training to learn how to administer and interpret the Autism Diagnostic Observation Schedule Second Edition (ADOS-2).

Awards, Scholarships, and Grants
May 2021
Walter R. Borg Scholarship: Applied Practice and Research Award
USU Psychology Department
Description: For excellence in research and applied activities.

May 2019
Kenneth W. Merrell Scholarship
USU Psychology Department
Description: For outstanding academic achievement, commitment to the field of School Psychology, and involvement in school psychology activities outside of the specialization requirements.

May 2018
Psi Chi Regional Travel Grant – RMPA

Research Grants
Summer 2020
Psi Chi Mamie Phipps Clark Diversity Research Grants - Executive Functioning in Children with ASD and Comorbid Neurodevelopmental Disorders

Fall 2019
Graduate Research and Creative Opportunities (GRCO) - Perceptions and Knowledge of Neurodevelopmental Disabilities Among Navajo Parents and Education Professionals

Summer 2019
Psi Chi Mamie Phipps Clark Diversity Research Grants - Perceptions and Knowledge of Neurodevelopmental Disabilities Among Navajo Parents

Professional Affiliations
American Psychological Association of Graduate Students (APAGS)
American Psychological Association (APA)
International Society of Autism Research (INSAR)
National Association of School Psychologists (NASP)
Utah Association of School Psychologists (UASP)
Psi Chi International Honor Society in Psychology